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Ham Radio Above 50 MHz

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Winter 2012

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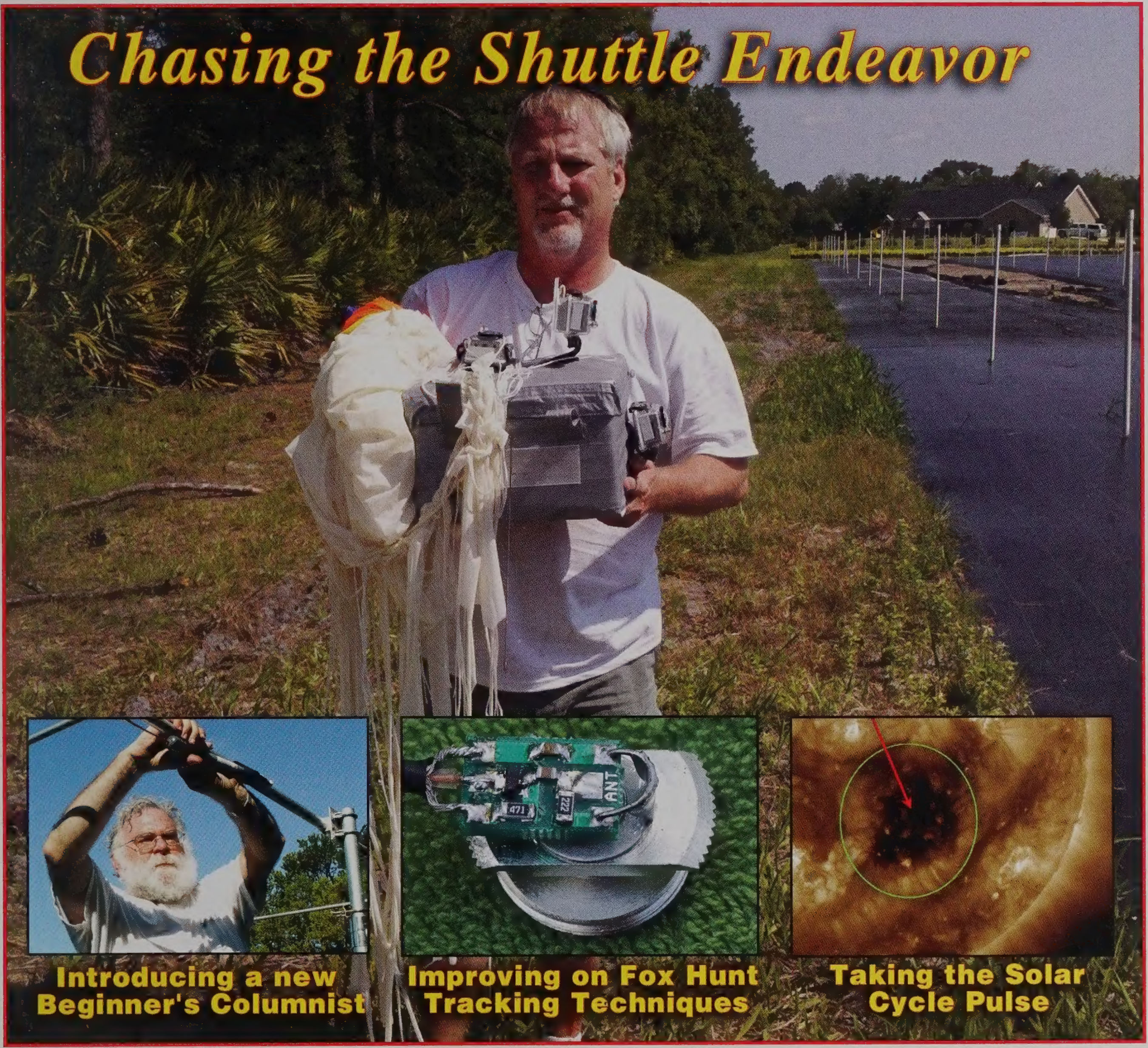

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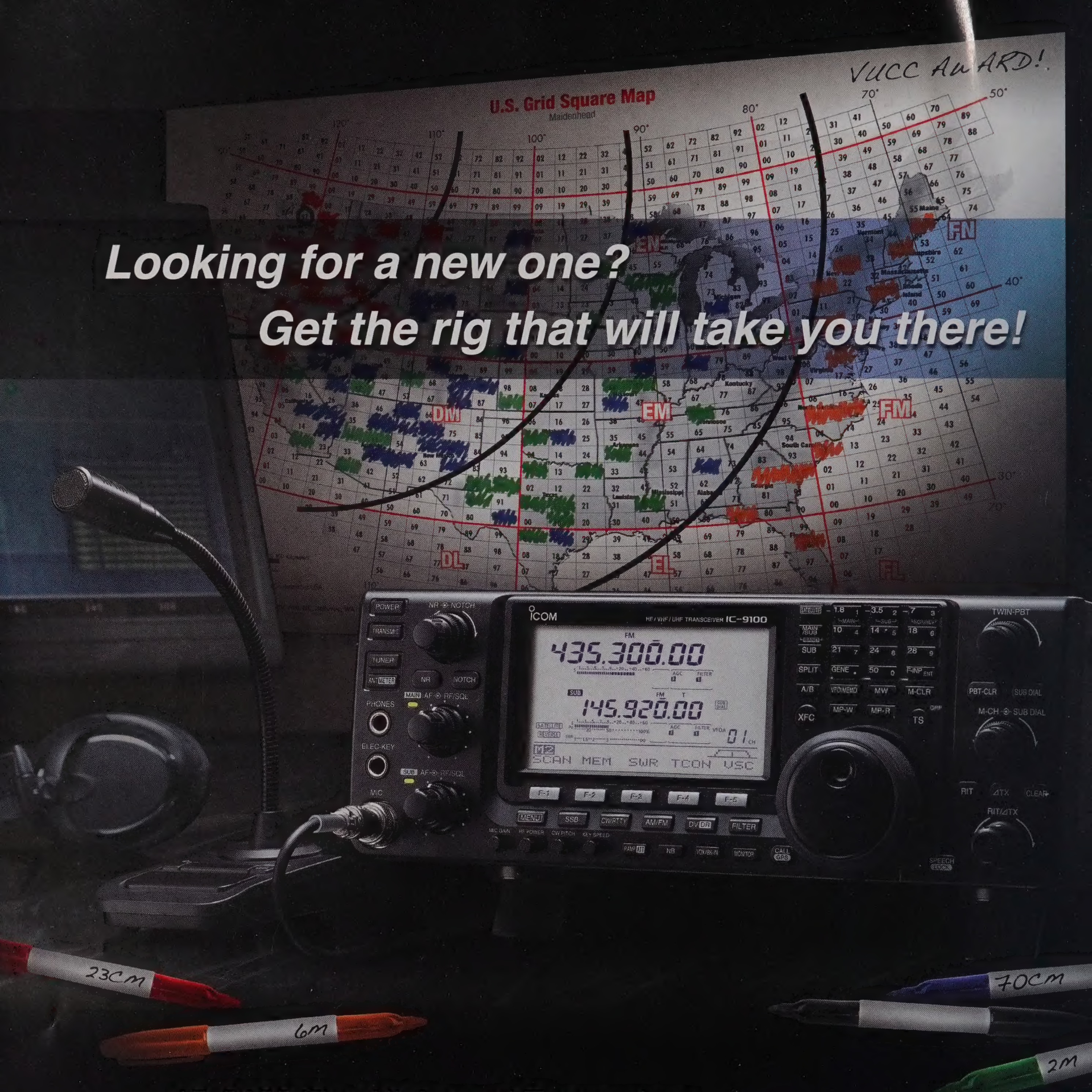
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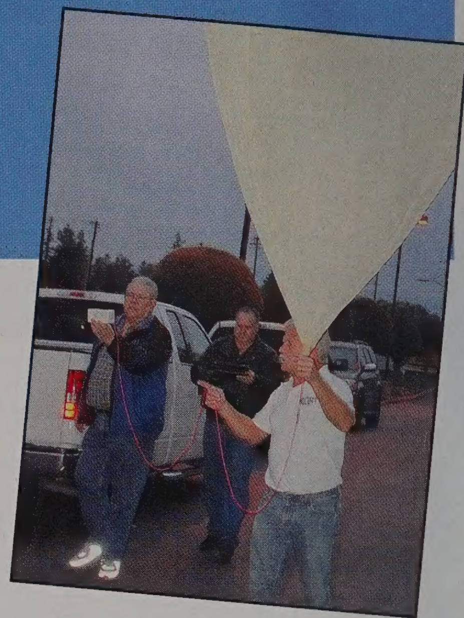

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CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Up and Away

Perhaps Ron Meadows, K6RPT, a child of the 1960s, was thinking about Jimmy Webb's 1967 hit song *Up, Up and Away,* which was made popular by The 5th Dimension, when he released the CNSP-11 (*aka* K6RPT-11) balloon. Perhaps he was wondering if it might be seen by anyone driving on the highway in the background of the accompanying photo.

Perhaps also in his thoughts was the *remote* possibility that it *might* cross the Atlantic Ocean. After all, it was one of four balloons launched on that mid-December day last year: Two for distance, this one and CNSP-12 (K6RPT-12), and two floaters, CNSP-13 (K6RPT-13) and CNSP-14 (K6RPT-14).

The two distance balloons lived up to their expectations. Tracking them across the country became an exciting adventure. CNSP-12 came down first, the next day, in southern Indiana. Howard Brooks, KC9QBN, of the Balloon Assisted Stratospheric Experiments (BASE) project of DePauw University in Greencastle, Indiana, graciously retrieved the payload.

While word of CNSP-12's recovery was received, tracking of CNSP-11 continued and continued and continued. "Up in the Air" Columnist Bill Brown, WB8ELK, tells the rest of the story in his article "Cross Country and Trans-Atlantic Amateur Radio Balloon Flight," which begins on page 8.

Chasing Endeavor

On May 16, 2011, the shuttle *Endeavor* took off from the Cape Canaveral launch pad for its last trip into space. Unknown to the astronauts onboard was that as the *Endeavor* was making its skyward arc toward Earth orbit, standing by in the sky was a weather balloon named Senatobia-1 with a camera in its payload, ready to take the shuttle's picture.

In the Fall 2011 issue of *CQ VHF* magazine, John Pugh, KJ4YNE, wrote about his group's (Quest for Stars, <http://questforstars.com>) efforts to take a similar picture of the last launch of the shuttle *Discovery*. In this issue, Pugh continues is storytelling with the second installment on *Endeavor*, "Chasing *Endeavor*," which begins on page 13. Pugh's third article, tentatively entitled "Chasing Atlantis," is scheduled to appear in the Spring 2012 issue of *CQ VHF*.

More on Propagation

Another series of articles features propagation. Author Jim Kennedy, KH6/K6MIO, along with his co-author, Gene Zimmerman, W3ZZ, write about East-West Extreme E_s (EWEE, with the last E meaning sporadic-*E*). In commenting on their article, Kennedy stated in an e-mail to me, "I think we did come up with some valuable insights (if they stand the test of time)—for example, the value of viewing the (diurnal) E_s variation in time as a propagation map in space along a path, and the early-on-late E_s propagation windows effect. These provide good explanations for the times of day that EWEE is seen to occur." Their article begins on page 20.

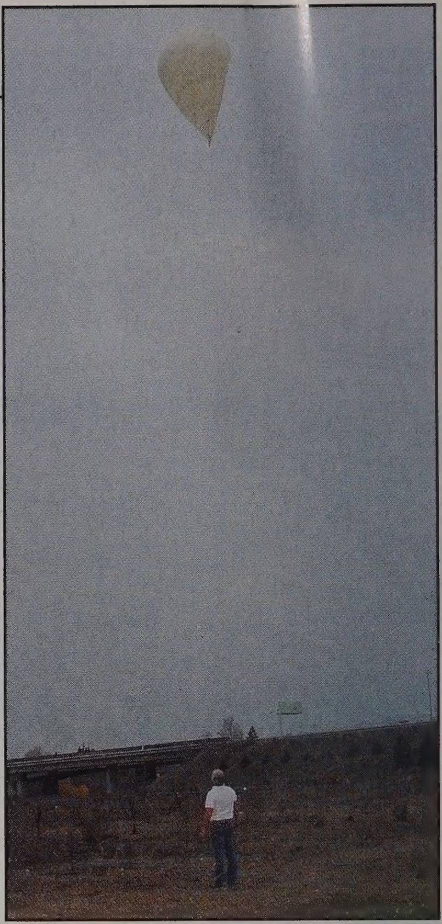
Another article on propagation, *F2* propagation in particular, by Ken Neubeck, WB2AMU, begins on page 36. In his article, he comments on sunspot Cycle 24's unpredictability, adding: "Cycle 24 may not be a bust after all."

Construction

Two articles related to construction are in this issue: Pete Manfre, WA2ODO, contributes the first part of a series of articles on building ultra-low-noise preamps, beginning on page 40. A slightly updated version of Fred Stefanik, N1DPM's paper "One-KW Solid State Amplifier for 144 MHz Using the NXP BLF578 Push-pull Transistor" which originally appeared in the *Proceedings* of the Microwave Update 2011 and 37th Annual Eastern VHF/UHF Conference, of the Eastern VHF/UHF Society, begins on page 43.

New Columnist

Because of increased responsibilities, "Beginner's Guide" columnist Rich Arland, K7SZ, has had to step down. I thank Rich for his many contributions to the pages of *CQ VHF*. Rich recruited his replacement, James Duffey, KK6MC, whose first column begins on page 64. You will read that Jim has a long history of involvement with the VHF-Plus ham bands. He brings his knowledge and experience to the Beginner's column.



Ron Meadows, K6RPT, watches as the K6RPT-11 balloon begins its ultra-long journey. (Photo courtesy KG6TBY)

Errata

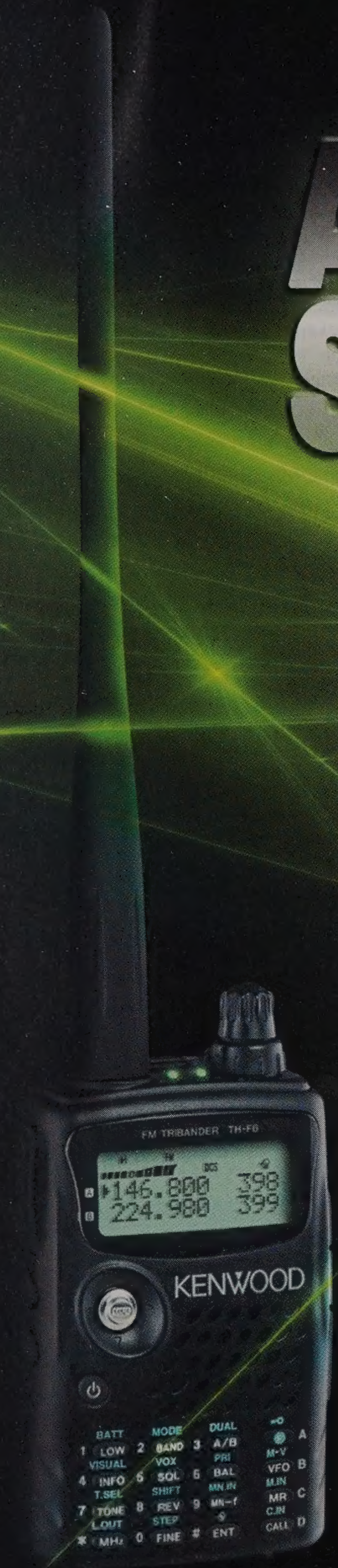
Jim Kocsis, WA9PYH, gives a substitute fix for an unobtainable part in his AZ-EL rotator article that appears in the Fall 2011 issue of *CQ VHF*. His fix can be found on page 35.

And Finally . . .

Within this issue of *CQ VHF* magazine are several articles that are parts of series of articles. Having these series provides continuity for this, your magazine. Perhaps you may have a series of stories to tell or a series of construction projects to describe. If you would like to use this magazine as your venue, then please contact me at:< n6cl@sbcglobal.net>.

Again, thank you very much for your ongoing support for your magazine covering the wonderful world of the VHF-Plus amateur radio frequencies.

Until next time . . .73 de Joe, N6CL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QUARTERLY CALENDAR OF EVENTS

Current Contests

The **European Worldwide EME Contest 2012**: Sponsored by DUBUS and REF. The EU WW EME contest is intended to encourage worldwide activity on moonbounce. Information for this contest is available at this website: <http://www.marsport.org.uk/dubus/>.

Spring Sprints: These short duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. Please check with N6CL's "VHF-Plus" column in *CQ* magazine for a future announcement.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs the second weekend of May. Rules are available at the following URL: <http://www.ham-radio.com/sbms/>.

The **June VHF QSO Party** will be held during June 9–11, 2012.

Conference and Convention

Southeast VHF Society: The 16th annual conference will be hosted in Charlotte, North Carolina, April 20–21, 2012. For information on registering for the conference, please check the society's website at <http://www.svhfs.org/>.

Dayton Hamvention®: The Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 18–20, 2012. For more information, see: <http://www.hamvention.org>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings*, or both. For more information, questions about format, media, hardcopy, e-mail, etc., please contact the person listed with the announcement. The following organizations and/or conference organizers have announced calls for papers for their forthcoming conferences:

Southeastern VHF Society Conference: Technical papers are solicited for the 16th annual Southeastern VHF Society Conference to be held in Charlotte, North Carolina on April 20–21, 2012. Papers and presentations are solicited on both the technical and operational aspects of VHF, UHF, and Microwave weak-signal amateur radio. In general, papers and presentations on non-weak-signal-related topics such as FM repeaters and packet will not be accepted, but exceptions may be made if the topic is related to weak signal. For example, a paper or presentation on the use of APRS to track rovers during contests would be considered. For further information about the conference *Proceedings* deadline, see the society's website: <http://www.svhfs.org>.

Central States VHF Society Conference: Technical papers are solicited for the 46th annual Central States VHF Society Conference to be held in Cedar Rapids, Iowa. For more information please see the society's website: <http://www.csvhfs.org>.

Meteor Showers

The *α-Centaurids* meteor shower is expected to peak on February 8. The *γ-Normids* shower is expected to peak on March 14. Other February and March minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids*, February 1*; and *χ-Capricornids*, February 13*.

Quarterly Calendar

The following is a list of important dates for VHF Plus enthusiasts:

February 7	Full Moon
February 8	The *α-Centaurids* meteor shower peak
February 11	Moon perigee
February 14	Last quarter Moon
February 21	New Moon
February 27	Moon apogee
March 1	First quarter Moon
March 3-4	First Weekend of DUBUS EME Contest
March 8	Full Moon
March 10	Moon perigee
March 15	Last quarter Moon
March 22	New Moon
March 26	Moon apogee
March 30	First quarter Moon
Mar. 31-Apr. 1	Second Weekend of DUBUS EME Contest
April 6	Full Moon
April 7	Moon perigee
April 13	Last quarter Moon
April 20-21	The Southeast VHF Society Conference
April 21	New Moon
April 21	The *Lyrids* meteor shower
April 22	Moon apogee
April 28-29	Third Weekend of DUBUS EME Contest
April 29	First quarter Moon
May 5	The *η Aquarids* meteor shower peak
May 6	Full Moon
May 6	Moon perigee
May 12	Last quarter Moon
May 18-20	The Dayton Hamvention®
May 19	Moon apogee
May 20	New Moon
May 20	Solar eclipse
May 26-27	Fourth Weekend of DUBUS EME Contest
May 28	First quarter Moon
June 3	Moon perigee
June 4	Full Moon
June 4	Lunar eclipse
June 9-11	ARRL June VHF QSO Party
June 11	Last quarter Moon
June 16	Moon apogee
June 19	New Moon
June 23-24	Fifth Weekend of DUBUS EME Contest
June 27	First quarter Moon
June 27	The June *Boötids* meteor shower peak

The *Lyrids* meteor shower is active during April 16–25. It is predicted to peak around 0530 UTC on April 22. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility of upwards of 90 per hour.

A minor shower and its predicted peak is *n-Puppids* (peak on April 24). Other April, May, and June minor showers include the following and their possible radio peaks: April *Piscids*, April 20; *δ-Piscids*, April 24; *η-Aquariids*, May 6; *η-Lyrids*, May 9; *ε-Arietids*, May 9; May *Arietids*, May 16; and *o-Cetids*, May 20. June *Arietids*, June 7*; *zeta-Perseids*, June 9*; June *Boötids*, June 27, 0300 UTC; and *β-Taurids*, June 28. An asterisk (*) indicates that the shower may have multiple peaks.

For more information on the above meteor shower predictions please see Tomas Hood, NW7US's "VHF Propagation" column beginning on page 72, as well as visit the International Meteor Organization's website: <http://www.imo.net>.

Leveraging SDR for Better Digital Mode Communications

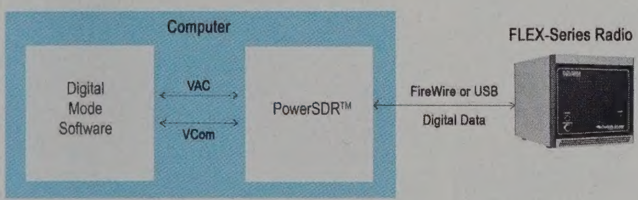
FlexRadio Systems PowerSDR™ Advantage

History and the Problem

As computers and software grow more advanced, more and more digital modes have been added to the amateur's repertoire. Some of these modes include Olivia, RTTY, Clover, PACTOR, AMTOR, PSK31, MT63 and numerous modes supported by WSJT. Many of these modes are able to be modulated and demodulated in a computer and, as such, do not require and external modem device. For the modes supported in a computer, numerous software packages have sprung up that do everything from basic mod/demod all the way to complex contest support operations, logging and integrated spotting. While the software packages and the radio are both very functional as individual components, interfacing these two system components requires electronics, effort and quite often, an interactive try-this-try-that approach to remove interference and signal issues between the two components.

The PowerSDR Advantage

So how does an SDR help out with all of these problems? To understand this, we need to review the architecture of an SDR system. In the figure below, the digital data line represents the digital spectrum data and the radio control signals that are passed between the radio and PowerSDR™.



PowerSDR™ Digital Mode Connections

This data path is digital rather than traditional analog signals. A single cable between the radio carries the PTT signal for transmitting, as well as, both receive and transmit audio data. Since the data is digital, it doesn't suffer the same degradation that an analog signal travelling down an analog cable is likely to experience. This means your audio is ultra clean and cannot be degraded once it leaves the radio.

Once the data is delivered to the computer, PowerSDR demodulates the signal then passes it via a Virtual Audio Cable (VAC) to the users' digital mode software inside the computer. VAC was designed to be a "pass-through" that connects two digital sound programs as if each is seeing a sound card rather than another piece of software. A virtual interface also eliminates the need for additional cables, interface boxes and all the headaches related to interfacing in a high RF environment.

If the digital mode audio can be virtual, why not the control signals too? Using virtual COM port software, the user's digital mode software can be easily interfaced to PowerSDR for controlling frequencies and PTT signals. All with no more wires!

Further, once connected, this virtual digital mode interface requires no work on the operator's part -- he does not have to constantly adjust levels or protect the system from radio frequency interference. It just works.

Summary

Amateurs have come to recognize that SDR systems provide superior audio and filtering capabilities, but few are aware of the key advantages that an SDR brings to digital modulation schemes. These include:

- No additional wiring between the computer and the radio.
- No 3rd party interfaces to connect the computer and radio.
- No additional sound cards are required.
- Because all data is already digital when it leaves the radio, all signals are protected from degradation and interference typically encountered with traditional analog audio interfaces.

For more information or to download the full white paper on Digital Mode Communications, visit www.flexradio.com.

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Cross Country and Trans-Atlantic Amateur Radio Balloon Flight

Amateur radio history was made in mid-December last year while the amateur radio world watched in amazement as a weather balloon launched in the San Jose, California area kept going and going and going. Its ultimate destination was well beyond anyone's estimation, expectation, or imagination—the Mediterranean Sea, off the coast of Algeria, 6236 miles away from its launch. WB8ELK tells the fascinating story.

By Bill Brown,* WB8ELK

On December 11, 2011, Ron Meadows and his son Lee of the California Near Space Project (CNSP; see the URL: <http://www.californianearspaceproject.com>) launched from the heart of the Silicon Valley four high-altitude balloons carrying APRS transmitters. Two of these were attempts to set a new altitude record, and two were designed to be long-duration flights.

The two high-altitude attempts (K6RPT-13 and K6RPT-14) traversed the Sierra Nevada range with members of the Stratofox (http://www.stratofox.org) balloon chase team in hot pursuit. Although these two balloons did not go beyond Ron and Lee's previous record-breaking altitude of 136,545 feet, set back in October, they did land near the Groom Lake, Nevada area, better known as Area 51.

Area 51 is a highly secretive military base (a remote detachment of Edwards Air Force Base), the primary purpose of which supposedly is to support development and testing of experimental aircraft and weapons systems. Because of its highly secretive operations, it has attained the folkloric reputation of being a warehouse for unidentified flying objects, or UFOs, but that's another story. The identified flying objects of this story are those four balloons that were launched during that eventful day last December, one of which, for several days after its launch, because of its endurance, captivated and held the attention of several VHF-plus amateur radio operators

Photo 1. Inflation of the California Near Space Project balloon.

*CQ VHF "Up in the Air" columnist, 12536 T 77, Findlay, OH 45840
e-mail: <wb8elk@aol.com>

from around the world. The following is the story of those four meandering, history-making balloons, in particular the balloon that was designated CNSP-11, with the call sign: K6RPT-11:

Although the usual amateur radio high-altitude balloon mission bursts immediately after achieving peak altitude, it was discovered years ago that if you fly a large latex balloon with low lift and light-weight payload, you can sometimes achieve a condition where the balloon floats at high altitudes until the UV (ultraviolet rays from the sun) exposure in the stratosphere causes the latex to degrade, often taking over seven hours in daylight to achieve.

Pete Sias, NØOY, was one of the first to accidently discover this effect and managed to fly a balloon 700 miles in just 6 hours back in 2000. Since then I've done a number of flights (WB8ELK Hi-Ball series) to replicate this effect and managed to get a latex weather balloon to stay up 22 hours and to fly 1400 miles partway across the Atlantic Ocean.

One of the great goals for amateur radio high-altitude balloon groups has been the desire to fly a weather balloon across the Atlantic Ocean. I personally have splashed six payloads into the Atlantic making the attempt. Joe Mayenschein,

Photo 2. Launch of the record-breaking CNSP balloon. Left to right: Don Ferguson KD6IRE, John Corgan AE6HO, Ron Meadows, K6RPT (holding balloon), and Michael Wright, K6MFW. (Photo by Bob Snelgrove KG6TBY)

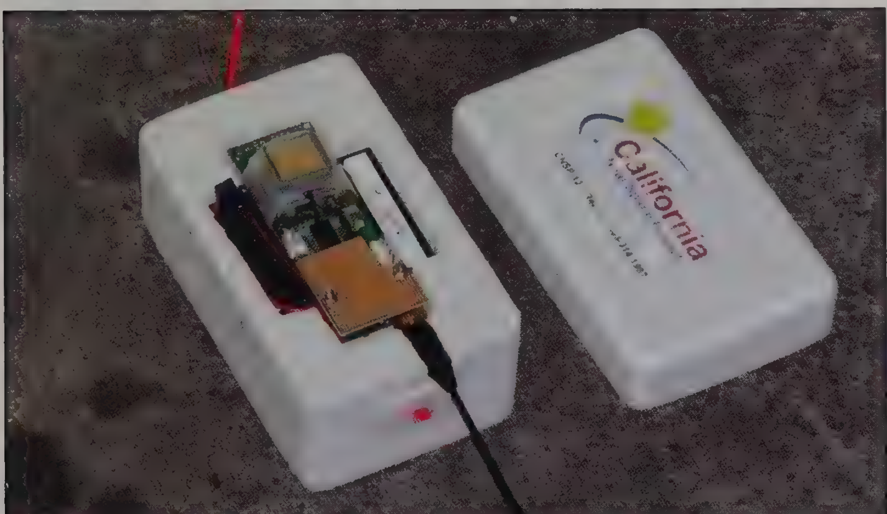

Photo 3. The K6RPT-12 APRS payload. (Photo by Don Ferguson, KD6IRE)

Photo 4. The K6RPT-12 payload landed in a tree in Indiana. (Photo by Howard Brooks, KC9QBN)

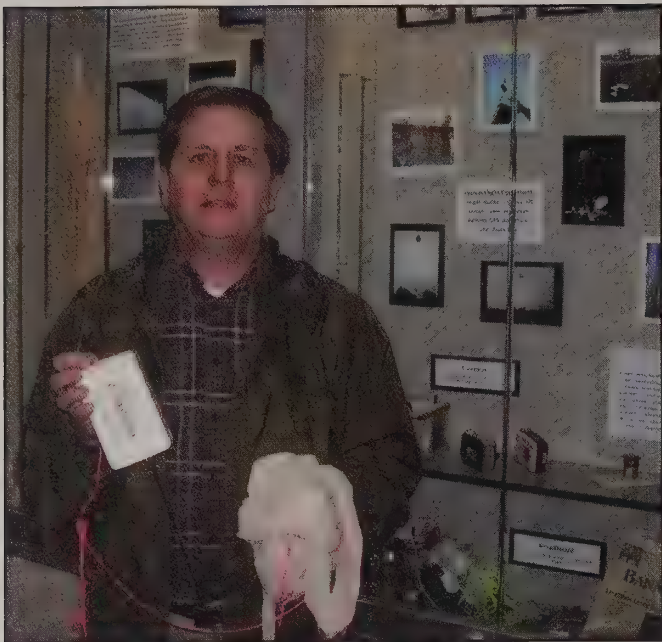

Photo 5. Howard Brooks, KC9QBN, of DePauw University recovered the CNSP-12 payload and what's left of the balloon in Indiana. (KC9QBN photo)

WB9SBD, of the Near Space Sciences group; Robert Rochte, KC8UCH; Dan Brown, K2VOL, of the White Star Balloon group; and the University of Tennessee Knoxville groups all have made trans-Atlantic attempts in the past. The University of Tennessee SNOX flight almost made it, coming within 300 miles of Ireland a few years ago.

In their effort at a sustained balloon flight, Ron and Lee designed a unique balance beam PVC filling apparatus that allowed them to inflate the two long-duration balloons with a precise amount of hydrogen. A very slow ascent rate combined with an extremely lightweight APRS transmitter payload that weighed just 5 ounces allowed the K6RPT-11 and K6RPT-12 latex balloons to float perfectly. The CNSP team got things just right and launched just after sunset to get a full night's flight without the worry of UV degradation.

Each of the balloons carried a lightweight BigRedBee model BLGPS 2-meter HP APRS transmitter with a built-in GPS receiver (http://www.bigredbee. com) powered by just four AA lithium batteries.

Race Across the U.S.

A few hours prior to the CNSP flights, Mark Caviezel, NGØX, decided to make a race out of it and launched his own long-duration floater flight (NGØX-11) from Oxnard, California. Although his payload froze up at night after flying across south-

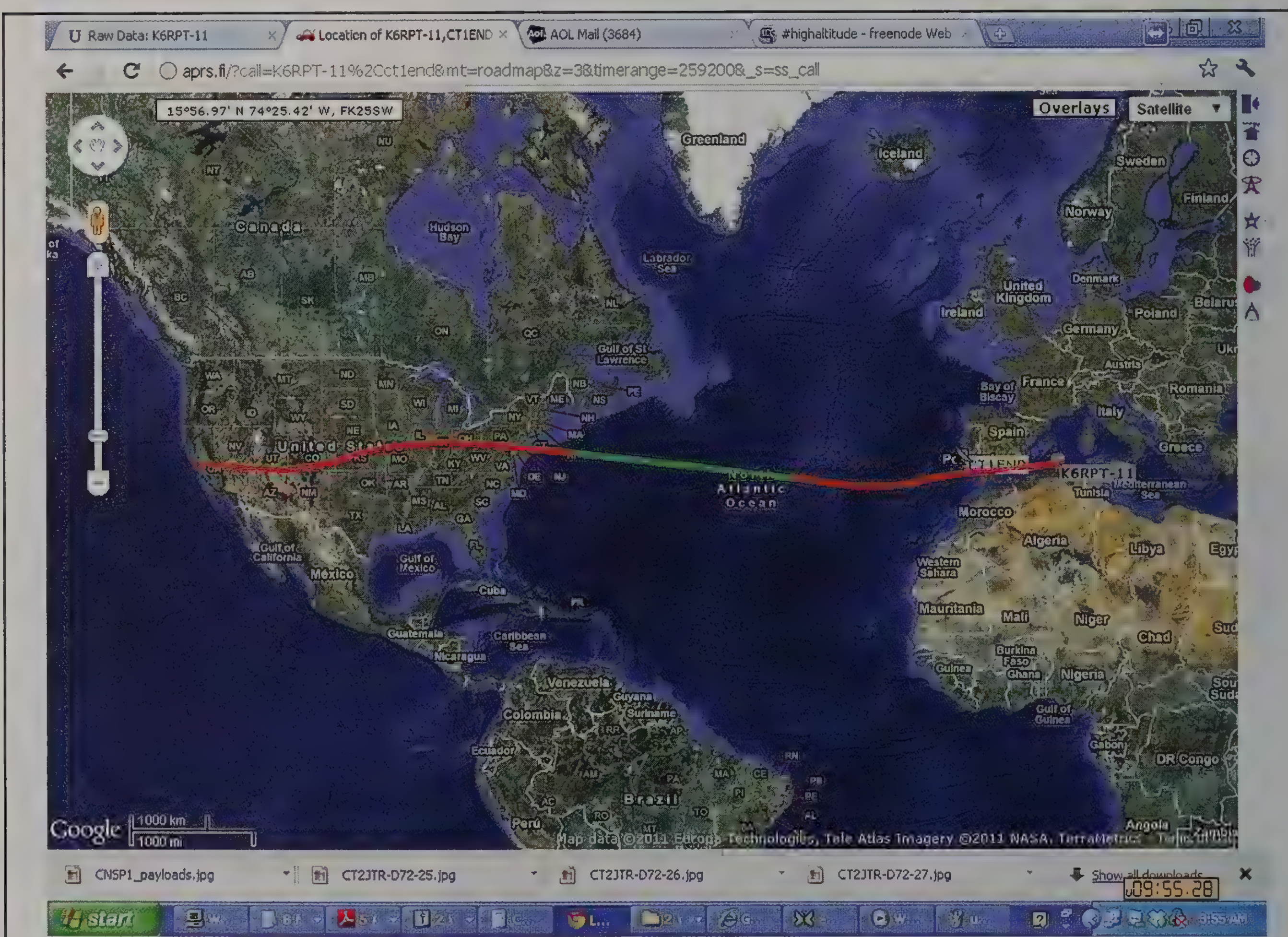

Photo 6. APRS tracking map of the record-breaking cross-country and trans-Atlantic flight of the K6RPT-11 balloon.

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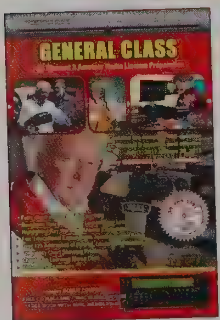

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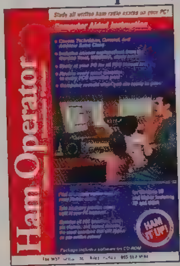

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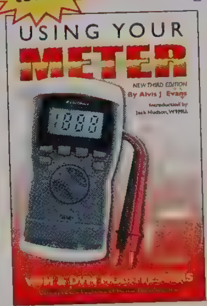

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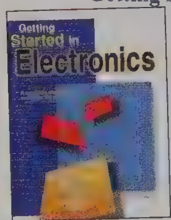

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ern California, we were surprised to see it come back to life over Kansas the next morning, flying just behind the K6RPT-12 balloon.

An exciting cross-country balloon race ensued until the UV exposure finally caused the K6RPT-12 balloon to burst over Indiana. The next day, Howard Brooks, KC9QBN, from DePauw University's (in Indiana) Balloon Assisted Stratospheric Experiments (BASE) balloon group (http://www.depauw.edu/academics/departmentsprograms/physics-astronomy/department-research/base/) recovered the payload from a tree southwest of Indianapolis

The NGØX-11 balloon froze up once again shortly after sunset after flying past Findlay, Ohio, still floating along around 98,000 feet up. While it is possible that it continued on toward the Atlantic, it never showed up again.

Trailing the pack was the K6RPT-11 balloon, which managed to survive a full day of sunlight and kept zipping along across the Midwest at 112,000 feet, traveling over 150 mph. This particular balloon was a new type from a company called Hwoyee (http://www.hwoyee.com), and the balloon apparently is tougher and more UV resistant. It continued effortlessly toward New Jersey and sailed off into the Atlantic that night until it travelled beyond the RF range of the East Coast digipeaters, thereby successfully completing the very first amateur radio balloon flight across the country.

Trans-Atlantic Success

You might think that once beyond digipeater range this would be the end of the story for the CNSP balloon. Through a miracle of international amateur radio efforts, e-mails were sent to hams in the Azores Islands, Portugal, and Spain to alert them to listen on 144.39 MHz for the balloon's APRS signals. In Europe the usual APRS frequency is 144.80 MHz, so this required the European hams to retune their APRS stations and digipeaters to our U.S. frequency.

Amazingly, thanks to reception reports from Associação de Radioamadores dos Açores, CU2ARA, in the Azores, the K6RPT-11 balloon showed up in the morning on the APRS maps southwest of the Azores, still at an altitude of 111,503 feet traveling over 162 mph to the east. This video shows one of the receptions of K6RPT-11: <http://www.youtube.com/watch?v=G0GzeMTEZM4&feature=youtu.be>.

Once out of range of the Azores, José Carlos B. Nora, CT1END, from Lisbon, Portugal picked up the signal from nearly 400 miles down range as the balloon headed toward Europe, while other hams in Spain started to retune their APRS systems. Tuesday was an exciting day, as many hams were glued to the APRS websites following the little balloon from Silicon Valley as it headed toward the coast of Spain.

History was made as the K6RPT-11 balloon crossed the southern coast of Spain near Chipiona, where Salvador Perez Lanzas, EA7FQB, more than 150 miles away in Malaga, picked up its packet. At that crossing point, while traveling at a speed of 153 mph and at an altitude of 109,708 feet, it became not only the first amateur radio balloon to cross the U.S., but also the first to complete the trans-Atlantic crossing.

After crossing southern Spain, Tom Orzaez, EA6WQ, and Enrique Muriel, EB6AOK, from the Balearic Islands, were able to track the balloon as it made its way into the Mediterranean Sea. Finally, after traveling 6,236 miles and staying aloft for an incredible 57 hours and 2 minutes, the balloon uneventfully popped and splashed down into the Mediterranean Sea off the coast of Algeria, setting world records for distance traveled and time aloft. The flight path can be viewed at this link: <http://aprs.fi/?call=K6RPT-11&mt=roadmap&z=6&timerange=259200&_s=ss_call>. More information on this historic flight appears in *CQ* magazine's February 2012 "VHF-Plus" column by N6CL.

The CNSP flight was an inspiration to follow your dreams. Sometimes when following your dreams the impossible may indeed be possible.

Special thanks go to Don Ferguson, KD6IRE, and members of the CNSP group for flight details and photos.

Chasing Endeavour

This article is part 2 of a 3-part series capturing the final flights of the US Space Shuttle program from a 20-mile-high vantage point. Part 1, entitled "Chasing Discovery," appeared in the Fall 2011 issue of *CQ VHF*.

By John Pugh,* KJ4YNE

On 16 May 2011 at 08:56 AM ET, Space Shuttle Endeavour (STS-134) lifted off from Cape Canaveral's Launchpad 39A. This would be the final flight of Space Shuttle Endeavour. Endeavour's payload carried the EXPRESS Logistics Carrier 3 (ELC3) as well as the Alpha Magnetic Spectrometer (AMS). Earlier the same morning a 1200g balloon lifted off from central Florida to capture the final launch of Space Shuttle Endeavor. This launch would be the second of three balloon launches to capture the final flights of the US Space Shuttle program. Both the Space Shuttle and the balloon launches would also continue to further challenge our nation's school systems to build up Science, Technology, Engineering, and Mathematics (STEM) educational programs. We learned a lot during the first launch, and this one had a lot more preparation.

Originally this launch was scheduled for 29 April 2011, but it was scrubbed early due to a malfunction in an electrical system on the spacecraft. One of the heaters for the fuel lines was "trending low" and out of limits for launch. While attempts were made to isolate the issue, it was determined that technicians needed access to the spacecraft to isolate the issue, and a scrub was ordered. It turns out the Aft Load Controller Assembly (ALCA) had an electrical problem that required replacement and complete system retesting, which pushed out the launch date for several weeks.

This was a blessing in disguise. My partner, Bobby Russell, KJ6KNA, returned to San Diego, California after several days and we then regrouped. The launch delay allowed us far more time to test and prepare with the equipment. We checked and double-checked the equipment, were able to test some changes, and set up better documentation for future launches.

The data from our earlier launch showed us that we still had some issues to overcome, with lens fog on the cameras. Everything else worked well, except that we found that having a better GPS antenna would allow us to gather data at a slightly higher altitude although civilian GPS use is limited above 60,000 feet. The rest of the data showed a flawless flight with our projections nearly perfect thanks to the University of Wyoming.

With everything charged up, preparation complete, Russell joined me back in Tampa, Florida on 14 May and we prepared for the launch. Space Shuttle Endeavour was tested, tanked, and ready to fly. Senatobia-1 was tested and ready to fly. The weather models were not looking great at the time, but we held out hope that all would be on our side to gather great data and beautiful shots of the final flight of OV-105/Endeavour.

The disguised blessing was a front that came through just as Russell was arriving from San Diego, which was a late season cold front bringing with it a stiff upper-level wind, clear air, and cooler temperatures—perfect weather for flying and wonderful late spring weather for central Florida.

Russell and I woke up quite early to finish loading up, since the launch window had to be pushed back to accommodate "catching up" to the International Space Station. The computer models showed that a location mid-state would prove to be the best launching point, so we chose a recreational area in Bronson, Florida for the launch. It turned out to be a perfect

Photo 1. The preparations and countdown went along perfectly with the launch of the balloon and payload performing without any issues whatsoever. (All photos courtesy of the author)

*e-mail: <pepelepugh@gmail.com>

spot with a large covered area and wide-open spaces to launch the balloon.

We arrived at the site at dawn with a chill in the air and the sun just starting to peek above the trees. This is a beautiful area surrounded by pine trees and away from the hustle and bustle of any large city with clean, clear air. We set up shop and began broadcasting around 0700 ET. A local newspaper reporter arrived and started taking photos for an article that was to run shortly after launch in the local newspaper. At this point everything was working perfectly and we continued preparations for launch.

The payload for this launch was similar to the last, with four GoPro™ cameras, two Motorola Droid™ phones, and a backup cell phone. We also had our trusty Byonics™ APRS transmitter with a shiny new GPS antenna. The students at High Tech High built the payload and tested all of the equipment prior to sending it in late April, and further checks at the home base in Tampa proved that their design worked perfectly. This flight would be the final precursor to our last shuttle capture flight later in the summer during which the High Tech High students were going to fly their video and flight capture payload in preparation for the next phase of the Quest for Stars space flight program.

The launch countdown and preparations went along perfectly (photo 1), with the launch of the balloon and payload performing without any issues whatsoever. Our countdown was choreographed by George Diller and the liftoff provided beautiful images of the launch area. Liftoff was at 0745 with the sun rising and not a cloud in the sky. As we packed up, we watched the balloon and its payload begin the ascent and start its flight along the path nearly identical to what was predicted. With the clear, dry air we had visual contact on the payload as it flew up through 5000 feet with ease. Everything was working as planned.

Our drive through the Ocala National Forest was uneventful. Tracking via APRS was working perfectly, and we were able to parallel the payload for most of the drive even though we could not gain visual contact. The balloon burst on the windward side of a fairly large lake and the trajectory was showing a splashdown. We started to get a bit worried that our payload

Photo 2. The payload landed in a pine tree with the balloon and parachute tangled high in the branches.

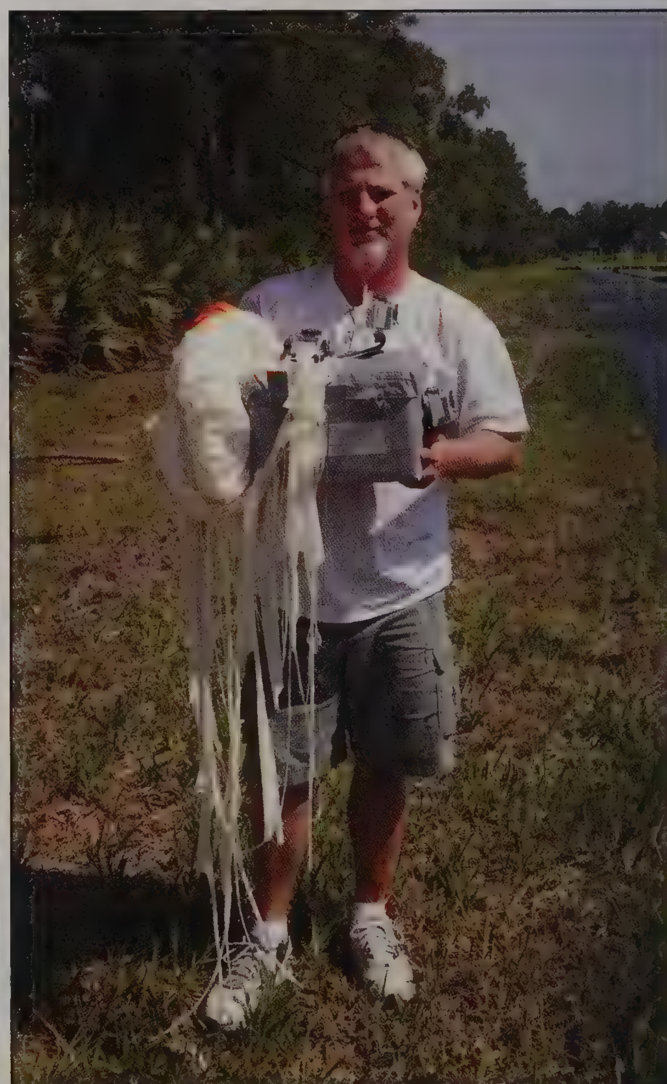


Photo 3. With about 30 minutes of effort we managed to get the payload, balloon, and parachute out of the tree and out of the bushes.

Photo 4. We also captured some wonderful pictures of OV-105/Endeavour's final liftoff even though we continue to be plagued with fogged-lens issues.

was going to get wet, but the landing prediction was not in that lake. We trusted the prediction, and sure enough, the winds at the 30,000-foot level were strong, blowing the payload to within feet of where our prediction had us landing.

We arrived at the landing site within minutes of landing and acquired visual contact nearly instantly. As is our luck, it landed in a nursery, Ava Nursery to be exact, and a quick phone call gave us permission from the owner to gain access to the property. However, the recovery was not that simple. The payload landed in a pine tree, with the balloon and parachute tangled high in the branches (photo 2). We plan for these contingencies by adding large amounts of lead line. What we didn't plan for was the huge saw-palmetto bushes in between us and the payload. I managed to get through them, get to the payload, and with about 30 minutes of effort we managed to get the payload, balloon, and parachute out of the tree and out of the bushes (photo 3).

We turned off everything and proceeded to head back to home base. Some clean-up of my self-induced saw-palmetto wounds and an uneventful drive back with a interim stop for some much-needed lunch allowed us to be analyzing data by 1400 ET. This data proved to be much better than that of the earlier launches.

The data gathered once again showed our prediction versus actual flight was nearly identical. We proved without a doubt that our prediction methods work, using all of the available data, and we can trust our predictions. We also captured some wonderful pictures of OV-105/ Endeavour's final liftoff even though we continued to be plagued with fogged-lens issues (photo 4).

With the support of the Motorola Foundation, the Challenger Center, and the Coalition for Space Exploration, we were able to capture pictures of the liftoff of the final flight of Space Shuttle Endeavor. The astronauts on board the International Space Station, along with visitors from Space Shuttle Endeavor, shared in the beauty of the spacecraft's flight, and NASA chief Charlie Bolden sent his congratulations to the team on capturing fantastic images of the flight. Success!

All of the data can be found at <http://questforstars.com>. Simply click on the Senatobia-1 mission patch on the home page for links to the videos, pictures, and details of the launch as well as recovery. All of the data collected on this mission proved that we are ready for our next phase with the final Space Shuttle mission and final flight of OV-104/ Atlantis later in the summer. Our last article in this series will highlight the beginning of our next phase in the Quest for Stars program, capturing the final flight of Space Shuttle Atlantis on STS-135.

Advanced Amateur Emergency/Medical Communications

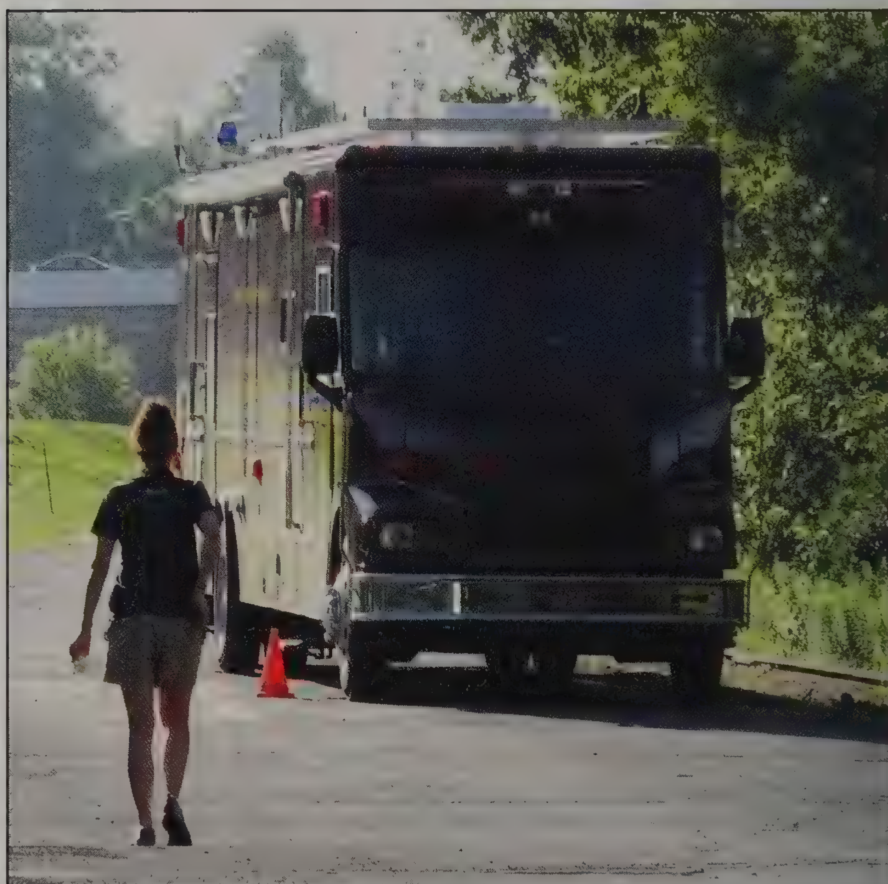
The old saying is experience is the best teacher. Here NY9D documents his and his colleagues' experience in emergency/medical communications so that we can learn from them.

By Erik Westgard,* NY9D

FCC Part 97, which governs amateur radio in the USA, does not envision a historical radio service. The words "advancement of the radio art" appear in the preamble, as does the task of providing trained operators for emergency communications. Our experience in very large public-service events over a decade suggests that the more up-to-date we are, the more our served agencies will partner with and depend on us.

In 2010, we were offered a planner role for the medical and communications aspects of a new running event with about 2000 participants. This was the Red White and Boom July Fourth Half Marathon and had the potential for an increased risk of runner injury due to heat.[1,2]

Federal requirements around the use of the National Incident Management System[2] do specify that emergency response be done as a structured team process. So while we are volunteer radio communicators, we are very familiar with how to organize an overall emergency response. After many years of working alongside medical staff, we also are comfortable building the planning framework for medical emergency responders to work under. In a real emergency, the idea is any member of an emergency response team would, if needed, step into the role of setting up the structure according to best practice and then finding resources and staff to get the formal response under way.



The Hennepin County Radio Truck. A single large command vehicle can handle several nets at a smaller event. At large events, we use up to four of these to decentralize and scale voice and data communications.[2] They often have built-in power and antennas to reduce setup and teardown time.

In a typical running race, the event provides a finish line medical tent and a series of aid stations. We prefer having medical doctors, especially those trained in sports medicine, to be the medical decision makers. Also, as they normally are a scarce resource, they provide supervision and protocols to a range of medical volunteers and first responders. We are very aware of the limits of simple field equipment, and need a way for the medical team to rapidly get patients to higher levels of care.

The first thing we do in the planning of these exercises is to talk to our vari-

*e-mail: <ewestgard@att.net>

A typical medical tent. The outdoor lounge chairs are lightweight and can elevate heads or feet depending on medical needs

ous team members—which include the event staff (Race Director usually), Medical Director, Emergency Medical Services partners, and government officials—to find out what their needs are. Then the fun part is to dig into our tool box of communications and organizational capabilities to give them what they request. We of course stay out of the "business" of the event. We are 100% focused on medical and disaster response—back to Part 97 and the role of emergency communications.

As ham radio operators we always start by establishing a voice ham net control and find enough operators to staff the aid stations. This provides an instant and highly reliable command and control network. We like voice radio nets, as they provide what is called in NIMS training a "common operating picture" to the management team.[2]

The next step is to get an ICS-202 form and draw out a rough plan. Almost always, a government official (in our case a County Emergency Medical Services Supervisor) is the formal Incident Commander. This does present an immediate challenge, as they usually have a government radio, and the rest of us on the leadership team don't. What we do at our events is have the Amateur Radio Net Control be in charge of the routine/event side of the communications system. They are partnered with the EMS side, and it works this way:

- Serious cases "runner down" go to 911/EMS, and if available, "arrest teams" with AEDs (automated external defibrillators) and the right training; the key is speed. More than once, we have requested EMS rigs via radio to our EMS partners when normal methods were not getting the job done. Hilly, wooded park land, and river valleys can be challenging for radio/cell coverage. This is part of our "backstop" role. We have a tight, pre-setup approved way to get to the 911/EMS center (usually via our Incident Commander) if needed via Net Control.
- Some cases, based on licensed medical judgment, are handled locally (ice packs, minor cooling, etc).
- Transportation of tired runners "SAG Wagons" are referred to the event staff.
- We do basic data collection (bib/race number and location only to avoid HIPAA disclosure) to aid families and tracking
- Hams, particularly out on the race course, can support medical logistics by setting up tents and cots and filling small ice bags for sore knees to free up the medical staff for patient care.
- If there is an incident declaration, we all are set up for the tactical command and control to switch from "normal routine/volunteers" to the designated formal Incident Commander.

This is all part of the plan. Some complicated issues include how to handle the range of medical volunteers we have. The idea is every aid station has event medics and ham operators. Bike medics, who are very mobile, are a great resource. Cell phones can be used, but there can be coverage issues. Often we rent commercial UHF/VHF/trunked handheld radios on a repeater for the overall event command and control net. These are answered by us as "Event Medical Control" in the same command center as our Ham Net Control. This way these radios can be handed to anyone. We ask the Incident Commander

to carry one, knowing he/she will use the government system they have as primary.

If you have a really big event and have some data needs, you need to add capabilities. At our largest events, we have several additional requirements:

1. Live data feed (such as Twitter). This keeps everyone informed of key events. If you have one voice net, you can listen in. We have four or five nets at our larger events. While this reduces span of control, information can become fragmented. We use a messaging feature of our Linux database system called Trivnetdb; each data operator is signed in and gets the messages and can also add messages. Ideally, a combination voice/data radio could be used here.

2. Database of missing/injured/transported persons. This is restricted to a race bib number as a key field (could be a phone number in an emergency not involving race participants) and location. These are entered by hams and then queried at the finish line or other places. Some events have used bar codes on the race bib to facilitate accurate data entry.[3]

3. Messaging. We have learned voice nets are easily saturated with traffic. A reliable messaging system is needed. We use Citadel, an open source mail, messaging, and conference system, on our five area D-Star digital rooftop backbone node systems.

4. Medical records. There is a lot of interest from our medical team in having access to medical records before starting treatment. The events ask runners to enter some medical details (including next of kin) in the online race application. This is then queried on a laptop flash drive by an operator at the front desk of the medical tent and provided to the doctor. Basic medical records (a one-page paper chart) are maintained during treatment and can be forwarded to the hospital if a patient is transported and/or retained for follow-up and research. There is strong interest in having this capability on personal wireless handheld devices. Electronic Medical Records are a part of modern emergency communications, but we keep this activity completely separated from our "in the clear/Part 97" radio networks. We use known, trusted operators to facilitate and manage the data, as this protects our medical team, who are at risk if the data is disclosed improperly. Some events have laptops and staff that has access to actual hospital medical records software and data.[4]

5. Family medical information. Particularly at sports events where there is an extended race course, there are always family members and friends looking for participants or even spectators who are missing. We use a "mashup" of data sources to help answer the questions. On a race with an internet/runner chip tracking system, we can look up a runner to see which course checkpoint or the finish line has been reached. Then we can look in our database system to see if a ham has reported them entering a SAG bus or medical tent. And finally, if their location is shown as a hospital or EMS rig, we can bring over the Medical Director or EMS Supervisor to privately discuss any medical issues with them.

6. Government-affiliated hams. At events we are huge fans of using volunteer hams affiliated with government agencies. These operators often are allowed to use the same radio systems and channels as our Incident Commander and are trained on procedures. We have had great success with the Hennepin County Mobile Corps, and it uses its communications truck. This vehicle has ham equipment and access to the various radio systems used by our government partners. With the explicit advance per-

mission of the Incident Commander, our Net Control Operator is able to use the same county talk group with EMS, and we can seamlessly interoperate and take direction.

7. "Transport desk." When runners are sent to the hospital, this needs to be tracked. This information cannot be broadcast in the clear, so is sent on cell phones (encrypted). In a dire emergency, a person number, condition code (green/yellow/red), and location could be used on radios. This is what our EMS partners do on their radios. A volunteer ham group affiliated with Ramsey County Emergency Services runs this for us. They also asked to use their assigned "cache radios"[2] for one of our events, as this is part of their training program.

8. Other volunteer groups. As other partners such as the American Red Cross, Mdewakanton Emergency Services, and school emergency medical training programs support our events, we need to tie them into our command and control system. In some cases, they all have access to a government radio system. In other cases, we give the leader of each group one of the rented radios. If we don't have either option, a ham radio shadow can be assigned.

9. Phone systems. Particularly with community volunteers, a plain telephone is a good way to communicate. We have now developed a five-station IP phone system based on a Linux "thin client" (tiny fanless, diskless computer), packaged open source PBX software, and IP/SIP telephones.

10. Wi-Fi networks. We are big fans of unlicensed Wi-Fi networks for communications among tents, etc. We carry a full range of external antennas, cavity filters, and spare access points. We have seen lots of RF interference issues and outright failures in outdoor conditions of access points, so we carry lots of spares. Someday a mesh network would be a good add-on to our capabilities.

11. Video and weather. At large events, live video feeds can help to locate injured persons, and good weather information can help to ensure that events are not operated during thunderstorms.

One of the best ways to ensure the continued viability of the Amateur Service is to get our best operators and data people involved in emergency planning. There are few more satisfying experiences than taking a technology project out of your workshop and using it to help injured people in a real-world situation.

Notes

1. Milwaukee Summerfest Rock 'n Sole 2011: <http://www.wisn.com/r/28503316/ detail.html>

2. Marathons are called out in the FEMA IS-700a NIMS course as a good place to practice emergency management techniques. <http://training.fema.gov/EMIWeb/is/is700a.asp>

3. <http://www.usatoday.com/news/ health/2006-04-15-barcode-marathon_x. htm>

4. <http://www.switched.com/2010/05/05/ detroit-marathon-using-electronic-medical-records-nation-should/>

Erik Westgard, NY9D, is employed in telecommunications and has served as the volunteer Medical Communications Director for the Medtronic Twin Cities Marathon for ten years. He has also set up the volunteer communications infrastructure for the Minneapolis Marathon and Red White and Boom Half Marathon, and led the development of the Minnesota Statewide Packet Network. He is a regular contributor to the *TAPR Journal* and *QST*, and serves on the community MIS faculty at Metropolitan State University in Minneapolis.

Extreme Range 50-MHz E_s: East–West (EWEE)

Following the first in this series, which appeared in the Fall 2011 issue of *CQ VHF*, this article discusses East-West Extreme E_S propagation in depth based on a broad range of observations and also comparisons with data-driven models of the ionosphere.

ByJim Kennedy,* KH6/K6MIO, and Gene Zimmerman, W3ZZ

This is the second in a series of articles (for the first, see "Extreme-Range 50-MHz E_s—nE_s or Chordal" in the Fall 2011 issue of *CQ VHF*) discussing the unusually long, yet still short-path, propagation events that continue to be seen on 6 meters in both the Northern and Southern Hemispheres. The first article mentioned above took a preliminary look at the essentially east-west path type, which is either entirely above, or entirely below, the equator. These paths are seen to reach out to about 11,000 km.

Han Higasa, JE1BMJ, originally labeled this as Short-path Summer Solstice Propagation (SSSP), in the belief that it was something other than E_s, due to its extremely long range (Higasa 2006 Japanese, 2008 English). However, the propagation seems to occur exclusively during the relevant hemisphere's local summer, strongly suggesting that some form of E_s mechanism(s) plays an important role.

The first article concluded that the JA–US path was consistent with either five-hop E_s ($5E_s$) *or* a combination of multihop E_s hops together with mid-path chordal (cloud-to-cloud) hops. It also showed direct observational evidence that at the *four-hop* range, *both* $4E_s$ and multihop E_s with intermediate chordal hops do occur, at times with comparable signal levels.

In view of that evidence, it suggested that it might be more appropriate to call the phenomenon East-West Extreme E_s (EWEE), because, taken literally, "Short-path Summer Solstice Propagation" describes virtually any kind of local summer E_s. Such a change also helps differentiate EWEE from another related, although importantly different, type of propagation that goes generally north and south, *always* crossing the equator, on even longer paths out to beyond 15,000 km. (This north-south propagation will be the subject of the third article in this series.)

What follows here is a deeper discussion of east-west EWEE propagation, based on a broader range of observations and then some comparisons with data-driven models of the ionosphere.

E-layer and E_s Review

Since some detailed ionospheric conditions will be discussed involving E_s and *E*-layer ionization, it will be helpful to take a quick look at how radio propagation works in that region.

The Sun and the Rain—of Meteors

The *E*-region of the ionosphere is generally considered to be the altitude range between 90 and 130 km. The ionization found at these levels arises from two main sources—solar radiation (at ultraviolet (UV) and soft X-ray wavelengths), and the vaporization of incoming meteors.

Every day an estimated 1,000 tons of very small meteoric particles hit the Earth's upper atmosphere. Most of these so-called *sporadic* meteors are smaller than a grain of sand. They do not appear to be connected with the larger swarms of meteors normally associated with the recurring meteor showers. Generally,

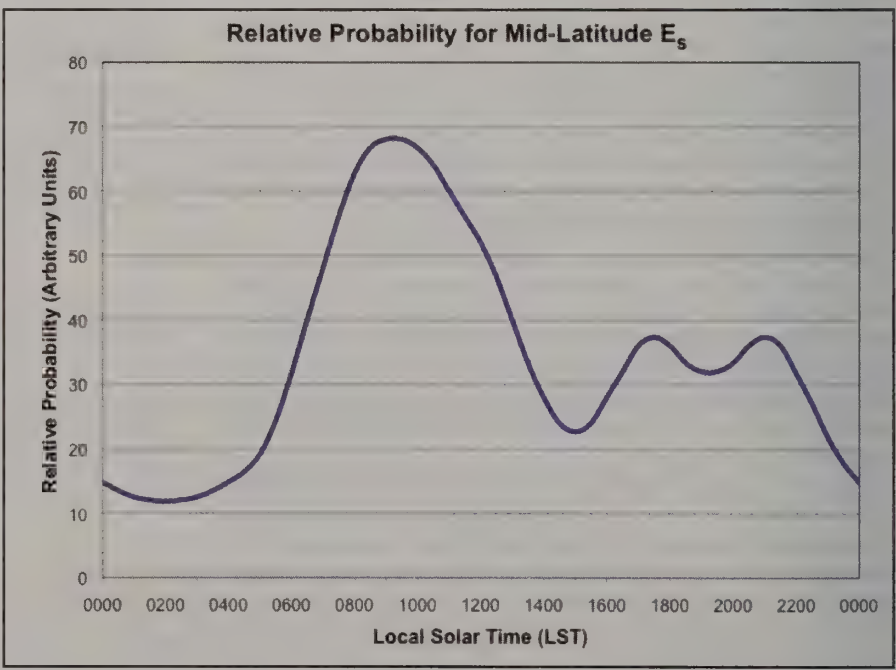


Figure 1. This stylized view of the typical diurnal behavior of mid-latitude E_s shows that the propagation probability often peaks during two time periods, a morning period and a double late afternoon and evening peak period.

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these particles are metal rich, containing nickel, iron, sodium, and a number of other elements.

Although the *E*-region atmosphere is very thin, it is dense enough for atmospheric friction to heat up and vaporize the incoming particles. The intense heat raises the particle temperature high enough to both vaporize the particles and also ionize them into positive metal ions and negative-free electrons.

Due to the electronic structure, greater mass, and high temperatures of the positive metal ion cores, the subsequent loss of free electrons due to recombination is a much slower process than that for the smaller, lighter background gases. As a result, the metal ions have longer lifetimes than those created by the Sun's UV and X-rays by photoionization.

As noted, meteors are coming in and producing ions all the time, day and night. However, the Sun only produces ions during the day (roughly 0600–1800 LST [Local Solar Time]). As a result, at a given point in the *E*-layer the total ionization from both the Sun and meteors is highest during the day, but does not go to zero during the night; the meteor component remains.

What may be surprising is that even in the daytime the large-scale *E*-region ionization is fairly weak. The ordinary peak daytime *E*-layer maximum usable frequencies (MUFs) are on the order of 16–22 MHz. Thus, something *else* has to happen to increase the local electron density by a factor of *ten* or more in order to produce an MUF above 50 MHz.

While there really is *no* additional source of *large-scale* ionization, it will turn out the combination of daytime solar and all-the-time meteor ionization does provide the *reservoir* of electrons needed to produce sporadic-*E*. Read on.

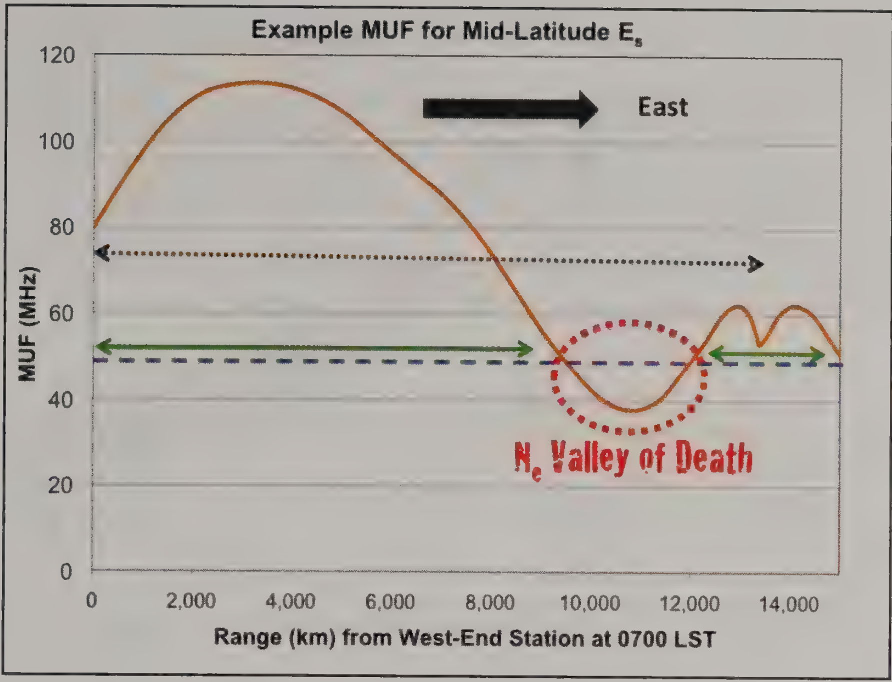


Figure 2. Remapping figure 1 shows the MUF as a function of distance from the west-end station at 0700 LST (30° latitude). The dashed line shows the 50-MHz MUF cut-off points. The solid arrows show the reachable paths. The dotted arrow shows what's possible if the valley is bridged.

Winds Aloft and Vertical Compression

As is the case in the lower atmosphere, there are identifiable wind patterns in the *E* region. There are recognized flows in both the *zonal* directions (east to west and west to east) and in *meridional* directions (north to south and south to north).

For example, the zonal winds, in combination with the Earth's magnetic field, seem to play a special role in enabling sporadic-*E* propagation below about 120 km. In the Temperate Zone, the Earth's magnetic field has a significant component parallel to the Earth's surface, and the zonal winds flow horizontally at roughly a 90° angle to that component of the field. As these winds blow, they try to carry both the neutral and ionized particles along with them. As the free electrons are dragged across the magnetic field, at roughly a 90° angle to the field, this produces a sideways electromagnetic force that bends the electron paths either upward or downward into orbits circling the field lines, rather than continuing to move along with the wind.

If the wind speed varies with altitude, there will be a wind shear at the boundary between the upper and lower flow. This produces net forces that push the electrons vertically into very thin sheets in the wind-shear region. The net effect is that the electrons, which originated in a rather *large* and *weakly ionized volume* of space, are then *compressed* vertically into thin sheets with *much higher* ion densities. This raises the *local* electron density (N_e), and with that, the MUF goes up —and E_s happens.

But then why doesn't this happen every day of the year?

Seasons and Meteors

Radar studies of incoming sporadic meteors have shown that there is a significant *seasonal* variation in the meteor counts at mid latitudes. In both the Northern and Southern Hemispheres the sporadic meteor count rates are three to six times higher in the hemisphere's local summer. This is due to the 23° inclination of the Earth's rotation axis to its orbital plane around the Sun (the tilt that causes the seasons in the first place). During the local summer, the hemisphere in question is aligned more directly with the plane of the Earth's orbit, and thus it is more nearly aligned with the direction of the Earth's orbital velocity, as it sweeps up the meteors, while moving around the Sun.

More importantly for radio propagation, there is a very *strong positive correlation* between the sporadic meteor counts and the E_s critical frequency (Haldoupis, et al., 2007): The higher the meteor count, the higher the MUF. The implication is that the enhancement of the general *E*-layer ionization, caused by the local-summer peak in sporadic meteors, increases the overall supply of electrons in the large-scale *E*-layer "reservoir." Then, as a *separate step*, when local conditions are right to trigger the wind shear and its vertical-compression effect, E_s occurs with MUFs that are much higher than they might be during the other seasons of the year. This appears to explain the summertime *major* E_s peak.

In the study cited, the radars were at 54.6° N and 38° N. They show clear indi-

cations of a minor winter meteor *peak* in early January roughly corresponding to the winter E_s peak, with the deepest *minimum* in mid February.

Another study (Younger, et al., 2009) shows strong summer meteor peaks at both 68°N and 68°S, with *no* winter meteor peak. Near the geographic equator (8°S), the seasonal meteor counts and seasonal variations are much less pronounced. Unlike the temperate region, there is a small meteor peak in both the summer *and* the winter.

With both studies taken together, the implication is that as one moves farther toward the equator from 68°, the summer meteor peak eventually begins to decline and the winter peak begins to emerge.

Atmospheric Tides and The Valley of Death

The Earth's atmosphere is an ocean of air. Like the ocean of water, it sloshes around, and it is subject to tidal forces from outside influences. While there are a number of different tides in the atmosphere, one of the most prominent outside influences is the heating of the atmosphere caused by the Sun every daytime. During the day the Sun heats the surface of the Earth, which in turn heats the air in the lower atmosphere immediately

Figure 3. The range between W7MEM and EU contacts (open bars) are compared to those between KØHA and JA (filled bars). The EU path shows typical evidence of both hops four and five. The JA path shows only hops two and five (see text).

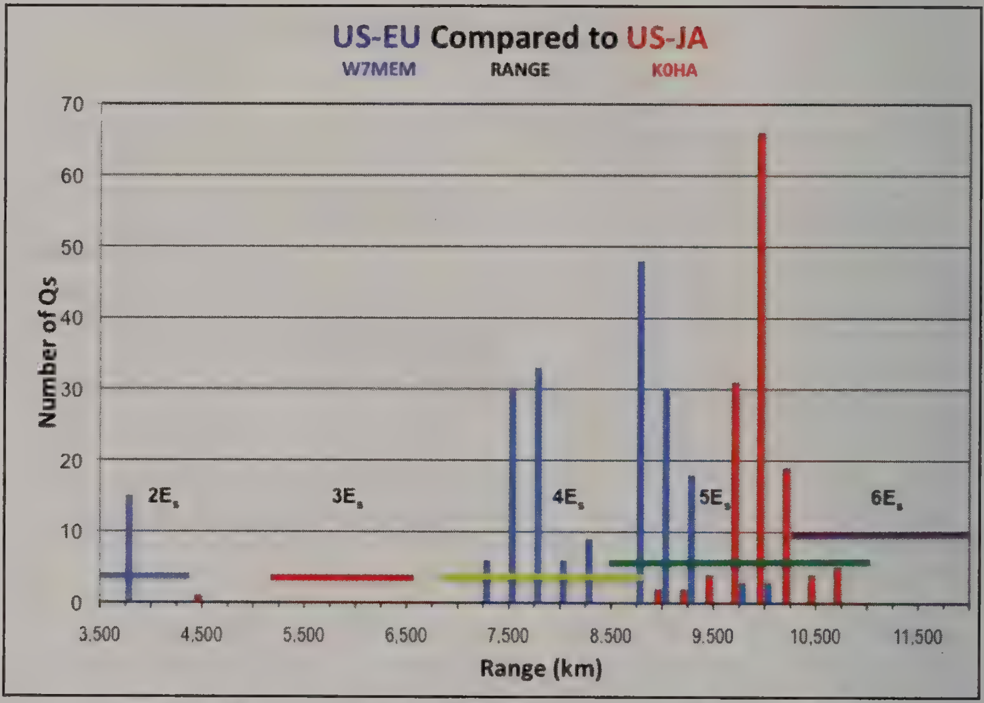
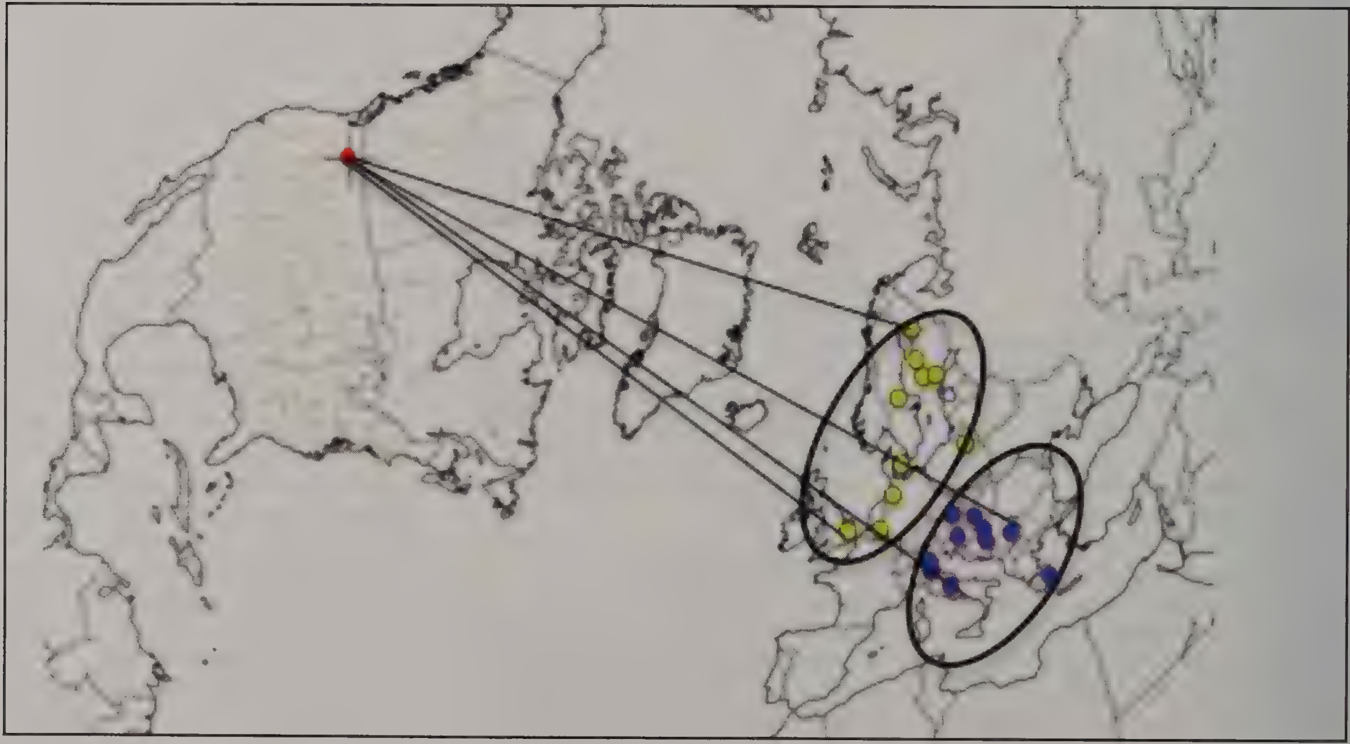


Figure 4. This great-circle map is centered on the average path midpoint. It shows the hops' four and five footprints in the two ovals on the right, with circles and dots at some actual contact locations. The straight lines show the azimuthal range of the signal ray paths, and the sparsely populated regions they traversed prior to hop four. (Background map credit: Joe Mack, NA3T, and Mike Katzmann, NV3Z; see <www.wm7d.net/azproj.shtml>)



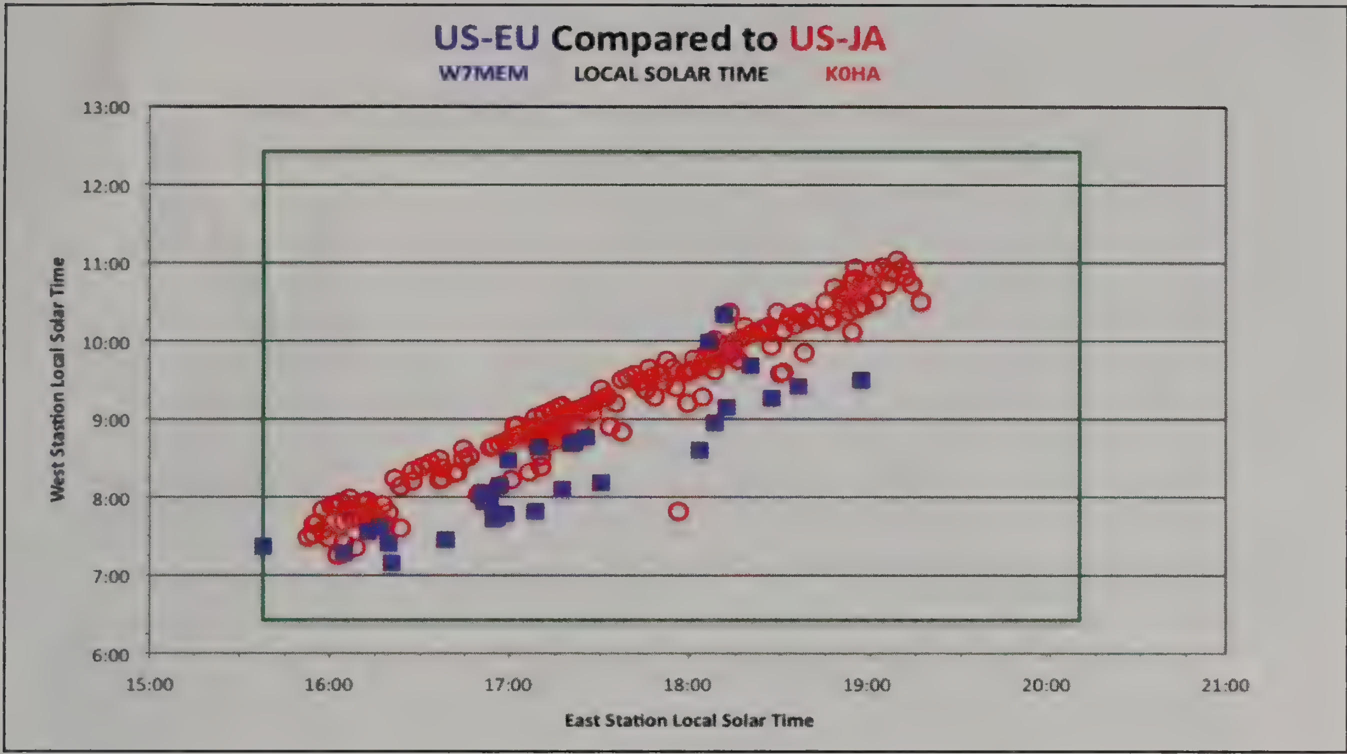


Figure 5. The circles represent each JA–NA contact LST at the west and east ends of the path. The squares represent the same for the NA–EU paths. Both clearly show the Early-Window-on-Late-Window effect.

above it. The heated air in that region expands, causing the dayside atmosphere to balloon upwards at all levels. The heating is more pronounced over land than it is over the ocean.

As the Earth turns under the Sun, this bulge follows the Sun, moving around the Earth once a day. In addition to this 24-hour tidal period, there also is a 12-hour tide and even an 8-hour tide (Haldoupis, et al., 2004). Of these, the 24-hour tide is the strongest, while the 12-hour one is next and the 8-hour somewhat weaker still. These tides produce systematic updrafts and downdrafts as they wax and wane. These vertical winds interact with the horizontal zonal and meridional winds to alternately enhance and diminish the vertical compression of the *E*-layer ionization.

The joint effect of these three tides seems to explain the well-known diurnal variations in the probability of E_s propagation. The overlapping of these three signals produces a three-humped probability curve, shown schematically in figure 1. The morning peak is consistent with the overlap of all three of the 24-, 12-, and 8-hour peaks, while the double-humped afternoon-evening peak appears to be a result of the overlap of the 12- and 8-hour peaks. After the end of the late window, the disappearance of the solar component of *E*-layer ionization leaves only the meteoric component. Consequently, E_s propagation above 50 MHz rarely occurs after midnight LST.

As was pointed out in the first article in this series, figure 1 can also be looked at in a different context, in which *time* is *fixed* at the location of the west-end station for a given family of propagation paths. If this is done, then the horizontal *time* axis in figure 1 can be reinterpreted as a corresponding *distance* axis, eastward from the west-end station.

Figure 2 shows what the propagation world would look like for the west-end station at 0700 LST. The MUF *probability* in figure 1 can be scaled as a *proxy* for the MUF itself. Figure 2 shows a schematic of the MUF to the *east* of the west-end station, now as a function of distance. In this example, the MUF minimum between the early window and the late window is shown dipping below 50 MHz. Evidence suggests that this is often the case. As a result, the only eastward stations accessible to the west-end station are those that are still in the same early window as the west-end station.

Much farther out, the stations within their late window can communicate with each other. However, the N_e electron-density gap in the middle (the N_e "Valley of Death") stops ordinary nE_s multihop propagation from going between the early and late windows.

That said, here are two obvious situations that would allow the early- and late-window stations to communicate with each other:

1. A chordal hop that bridges *across* the N_e gap (they require a much lower electron density than E_s; see "M-Factor" below), or

2. The overall E_s ionization is so high that the dip between the early and late windows never gets *below* 50 MHz anywhere (on a very good day, with very long nE_s).

As was noted in the first article, a key characteristic of EWEE is that the *west-end* station is almost always in its morn-

Hop	Min (km)	Max (km)
1	1,700	2,200
2	3,400	4,400
3	5,100	6,600
4	6,800	8,800
5	8,500	11,000
6	10,200	13,200

Table 1. Ground footprints for successive nE_s hops.

ing LST peak, at the same time the east-end station is in its afternoon-evening peak. It is possible that past 8,500 km chordal E_s *might* be more common, but longer paths have been seen with at least some ordinary nE_s hops (see figure 3).

Chordal Hops, MUF, and the M Factor

The suggestion that EWEE may include chordal skip mechanisms was partly motivated by the fact that a chordal hop can skip successfully with a much lower level of ionization, N_e. This is because the value of the MUF depends on both N_e *and* the *angle* between the signal ray path and the bottomside of the reflecting layer at the skip point. Expressed in MHz, the MUF is given by:

$$\mathrm{MUF} = \sqrt{N_e} \times (9 \times 10^{-6})$$

where N_e is electrons/m^3

M is the so-called M Factor, which is the cosecant of angle between the signal path and the plane of the skipping layer. As the angle gets smaller, M gets bigger. One gets a higher MUF *without* a change in N_e. (If N_e is expressed as electrons/cm3, the value of the constant is 9×10^{-3}).

The M factor seriously comes into play when one considers any of the chordal-hop variations. All of these involve signal ray paths that have been modified from normal nE_s angles into very shallow ("grazing incidence") angles, which can greatly increase the M factor, leading to a higher MUF for that hop than would be possible for nE_s. Put in different terms, in principle, chordal signals can skip successfully with a lot lower N_e than can nE_s.

It is fairly common for E_s clouds to be tilted with respect to the ground, sometimes as much as 60° (Whitehead 1997). Typically, what happens in a chordal situation is that the upcoming signal ray from the antenna on the ground first hits a tilted or curved cloud at what is now a shallow angle and is bounced off, more or less parallel to the ground. From there it might skip off of one or more flat E_s clouds and still not come to the ground until it finds another tilted cloud that points it back down again. All of these hops would require much less N_e than a traditional nE_s path.

Some Other E_s Important Characteristics

Sporadic-*E* has a number of features that make it rather distinct from *F2*. It occurs at a height of about 90 to about 150 km (most commonly below 130 km), while *F2* is around 250 km and above. The lower *E*-layer height leads to shallower angles of attack for an upcoming wave, leading to higher values of the M Factor and thus higher MUFs than *F2* with the same levels of ionization.

The ionization formation process for E_s clouds is both very different and less well understood, compared to *F2*. A consequence of this different ionization mechanism is that the morphology of E_s clouds is also quite different from *F2*. These complex processes lead to a variety of strange circumstances:

- Cloud layers are very thin, tens of meters to a few kilometers.
- Clouds are smaller in horizontal extent than in *F2* region, averaging around 100 km.
- Large areas of ionization are composed of swarms of individual clouds.

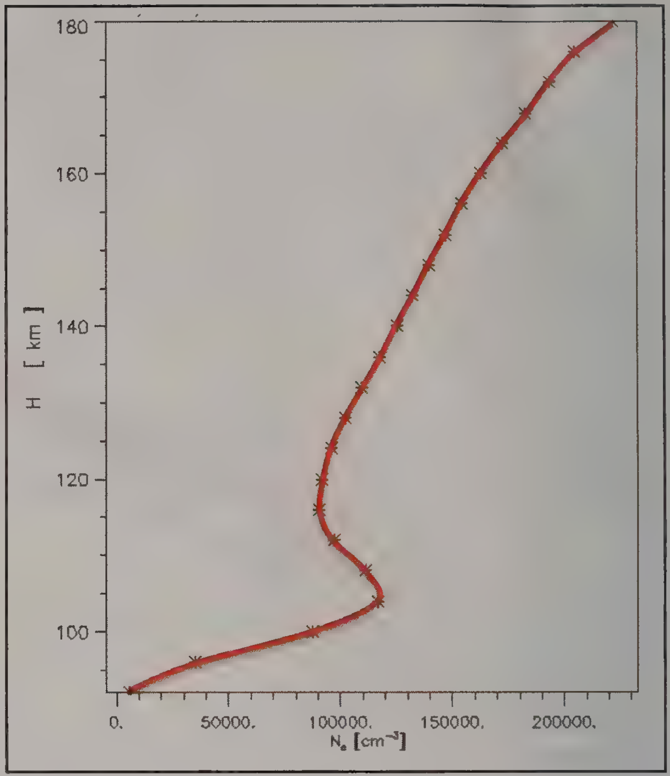


Figure 6. USU-GAIM N_e rendition for 0300 UTC 02/20/2010 at Lat –30, Lon 180. The E-layer peaks at 105 km, then drops by about 25% by 118 km, and then resumes increasing, going upward toward the F-layer.

- Clouds in the swarm are in motion horizontally and vertically (usually descending).
- Vertical stacks of two, three, or more layers are fairly common.
- Tilted layers are common, at times by as much as 60° with respect to vertical
- The underside of an individual cloud can be curved or rippled, rather than flat.

EWEE 2010

The first article in the series explored just the JA–NA paths. Since that time, a fairly large amount of 2010 northern summer data were compiled on both the JA–NA and NA–EU paths in order to characterize and compare these two different paths in more detail. Propagation reports were gathered from a variety of sources, including web-reflector postings and direct reports from the operators themselves.

In the end, the strategy was to select two different NA stations that had a lot of activity, one to JA (KØHA) and the other to EU (W7MEM), in an effort to get a coherent picture of paths radiating from one single starting point. In both cases, the data used for this report were from the openings of 19–20 June 2010. The intention was to establish a balanced view of what was taking place over essentially the same paths to those two remote destinations. As with the previous study, the idea was to look for evidence of chordal versus nE_s hops, and see if the diurnal "early peak on late peak" timing was indeed a persistent feature.

It must be pointed out that unequivocally demonstrating that a given 10,000-km path is the result of every hop coming to

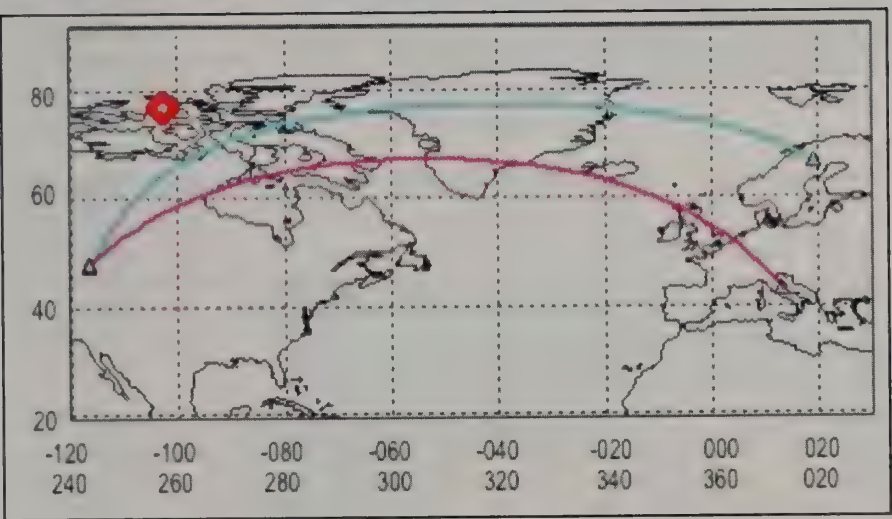


Figure 7. The 20 June 2010 NA–EU path extremes. The second longitude scale is in the "all east longitudes" notation used by USU-GAIM. The diamond near (80,–100) is the magnetic north pole.

Earth is a "hard" problem. The distances involved, the realities of geography, climate zones, human infrastructure, and human population demographics would make it a challenge to design an experiment where E_s of one form or another could happen *and* there would be a suitable population of radio operators in place and on the air at every hop footprint; ceans and polar regions are bound to get in the way.

JA–NA Path Ranges

Figure 3 shows a comparison of the JA and EU path data sets. The JA path result is much like the previous study. Except for a single KL7 at about 4,500 km, there is no other evidence of intermediate hops reaching the ground between NA and JA.

On that great circle path, the population of radio operators at all of the intermediate skip footprints (western Canada, Alaska, the Bering Sea, and the Pacific Ocean) is either very low or nonexistent. Consequently, it is still unclear whether these paths are nE_s or chordal E_s.

NA–EU Path Ranges

This is the first time the NA-EU path has been explored using the current techniques. Fortunately, this path's deeper end-point provides a bit more information.

There is clear evidence of hops two[1], four, and five reaching the ground. Single hop was ignored in the study; direct hops two and three land in the vicinity of Hudson's Bay and central Greenland and Iceland before making landfall in Europe. Looking more closely at figure 3, one can see at least two distinct populations of contacts at the four- and five-hop ranges, separated by what appears to be a skip-distance gap at about 8,500 km—where one would expect it—between hops four and five.

Figure 4 shows a great circle map centered on the average path midpoint. It shows the range of path tracks over the wilderness to finally reach the hops four and five footprints. Another interesting feature is the presence of multiple contacts from about 9,000 km to about 10,000 km, as hop five opened inland to central Europe and the Mediterranean. These are clearly at distances comparable to those required for the JA–NA path, and here those last two hops (at least) look very much like nE_s. Of course, there is nothing to say some hops might be chordal and others nE_s.

Early-on-Late Diurnals

The remaining measureables here are the details of the time-of-day relationships between the west-end and east-end station in each individual contact for both the JA and EU paths. The E_s morning probability peak is from about 0630 to 1230 LST, and the afternoon/evening peak is from about 1530 to 2030 LST (see figure 1). Figure 5 dramatically shows that *both* the JA—NA and the NA–EU contacts were made exclusively *within* this west-end east-end window overlap.

The LST time *difference* (9 to 10 hours on average) is set by the difference in longitude between the east-end and west-end stations. However, the *absolute* time of day is a free parameter. The fact that the actual LST at each end fits *within* the E_s peak probability times also strongly suggests that some kind of E_s mechanism is at work.

It also means that *if* a contact is in the LST early-on-late box, and *if* there is a Valley of Death, then the Valley lies somewhere in between the two stations.

ZL/VK–SA EWEE

The 2009–2010 southern summer provided a number of what appear to have been east-west EWEE contacts between ZL/VK and the SA west coast. Their characteristics seem to mirror those of the Northern Hemisphere effect. Only two or three such contacts have come to light in the 2010–2011 southern summer.

What Was Going on in the Ionosphere?

Clearly there are ionospheric processes going on that led to these uncommon forms of propagation. In order to explore this in more depth, an effort has been made to recreate the state of the ionosphere as it may have been while these events were occurring.

Ionospheric Models

Unfortunately, *directly* doing this in any detail, in three dimensions, by making measurements of the free-electron density, N_e, everywhere, is not currently possible. However, there are a large number of measurements of other relevant quantities that *are* made on an ongoing basis. So, while it is by no means trivial, it is possible to input those data into the known equations of the physics of the ionosphere to do a three-dimensional recreation, with generally good fidelity. There are a number of ionospheric modeling programs that do precisely that.

The model used here is called the Global Assimilation of Ionospheric Measurements model (USU-GAIM). It was developed at Utah State University (Schunk, et al. 2004). The ionospheric model was run for the entire day on the dates of the events studied. It produced a snapshot of the global ionosphere in three dimensions from 92 km to over 1,000 km for each 15-minute period through the day. The models were run at the Community

Coordinated Modeling Center hosted at NASA's Goddard Space Flight Center.

Although the USU-GAIM model is quite good, it is a large-scale, global model. It calculates values for every 4.66° of latitude and 15° of longitude. As a consequence, it cannot recreate small-scale or rapidly occurring events. This includes the many manifestations of E_s. The spatial features of typical E_s are made up of many relatively small clouds, which are often in rapid motion. As a result, the USU-GAIM model is used *only* to show the location and size of the *E*-layer electron "reservoir," and the approximate value of its electron supply. It *cannot* show when and where the E_s occurs, but only where it likely *could* be, *if* the vertical compressionion mechanism goes to work.

E-Layer Valley

As a general rule, if one plots the value of N_e starting at the surface going upwards, N_e increases with altitude until after the *F*-layer peak. However, there is an exception in the *E*-layer, which may turn out to be important to the discussion. *E*-layer N_e does increase with height, but only to a point (about 105 km in Figure 6) and then it actually goes down for a bit, before it begins to climb again. This feature is referred to as the *E*-layer Valley (Davies, 1990).

It demonstrates that there can be, in effect, at least *two* *E*-layer reservoirs to feed the formation of E_s. One corresponds to the region of the E-layer "peak" (here about 105 km), and another region of equal or higher N_e 10 to 40 km above the "peak" (here about 32 km).

It is an observational fact that E_s most often tends to be seen around 105 km. However, one or two additional layers *above* the lowest one are seen at times.

20 June 2010

This is a first look at a study in progress. A lot of the avail-

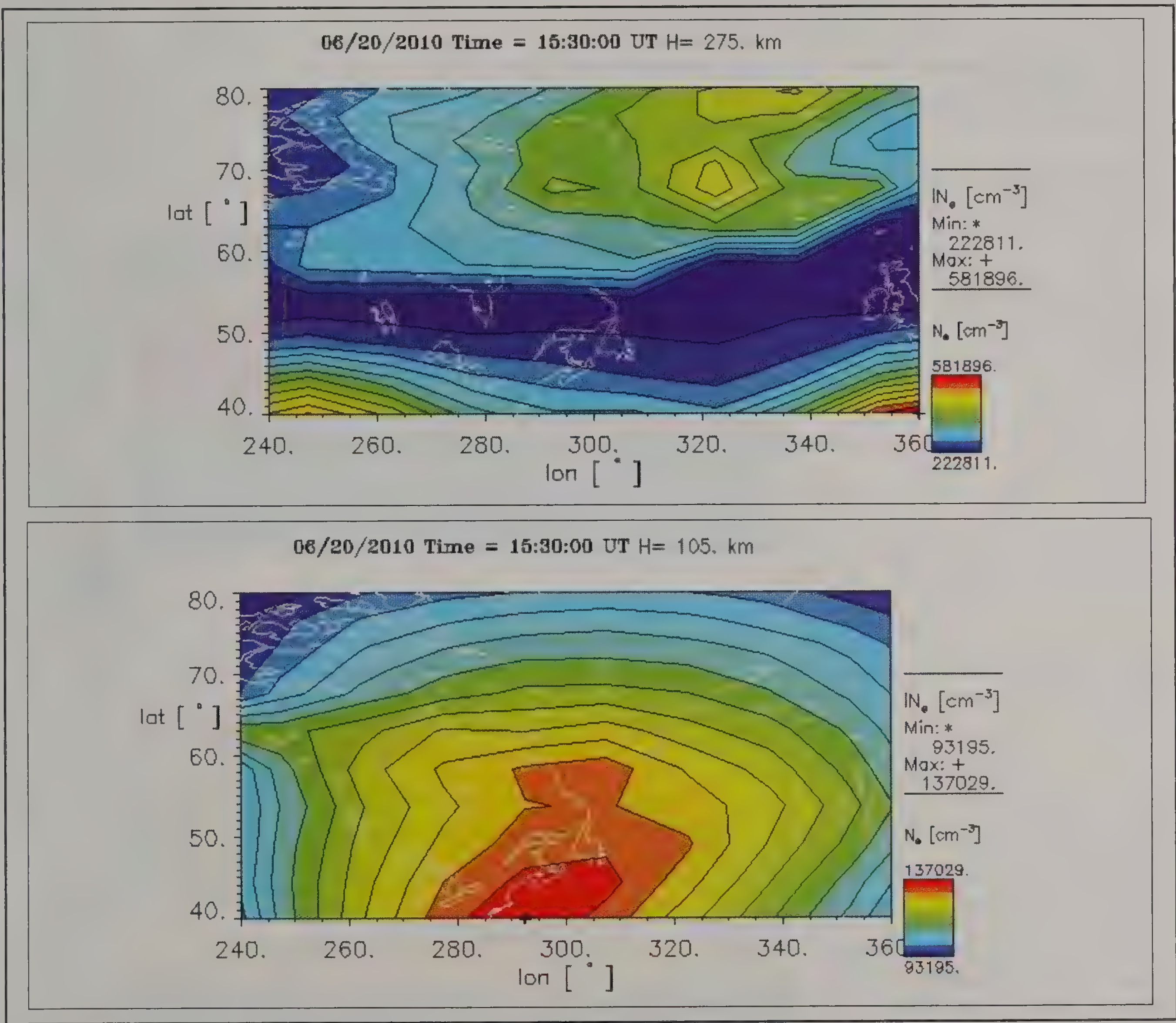


Figure 8. Upper: At the opening midpoint time, note that there is a "finger" of F2 ionization overlaying the central portion of the path region, with lower fringes reaching from south-central Canada to east of Iceland. The main F2 region is seen building south of 40N. Lower: At the same time, the E-layer at 105 km shows a broad area of available electron reservoir at good levels to feed E_s.

able detailed data have not yet been fully explored. However, samples from various dates indicate that they may have many characteristics in common.

The 20 June 2010 date was selected as the first for a more extensive review because from NA the band opened to EU in the morning around 0700 LST. As the Earth turned that same day, in the afternoon it opened from NA to JA at about 1600 LST (about 0800 JA). This suggested an opportunity to look at the evolution of the ionosphere over a roughly 13-hour period, where, perhaps, the same or similar conditions may have persisted.

NA–EU Path

Figure 7 shows the range of course lines for the W7MEM to EU paths, and the latitudes and longitudes covered. In latitude, the paths extend from about 40N to about 76N, and in longitude, from about 120W to 20E. There are also two longitude scales. The upper one is in the more common longitude east and west format, here running from 120W (–120) to 020E. The lower scale is an "East only" scale used in many of the USU-GAIM displays. It simply measures everything going eastward, from 000 through 360. This scheme will be used in most of the remaining maps.

E-Layer Reservoir

Figure 8 (lower) is a contour map of the modeled daytime *E*-layer reservoir, showing its broad expanse. Though N_e levels are decreasing to the north, they are adequate for • formation of over the path in question.

Arctic *F*-Layer Finger

The contour map of the *F2* region in figure 8 (upper) shows that there was a *separate F2 finger* centered over Greenland at 69N and 275 km (top half of frame). It is quite separate from the *main* daytime equatorial-anomaly *F2* ionization lobe (out of frame at bottom). This structure was centered very close to the figure 7 path midpoint, and it was elongated in the east-west direction.

While this discussion is not about *F2* propagation, hold on to the thought that this enhanced *F2* ionization generally *overlays* the main portion of the E_s paths between W7MEM and EU.

USU-GAIM is a 3D model. Figure 9 shows a vertical north-south slice down through the *F2* structure along longitude 310E. It shows how this structure dominates the region from about 55N to past 80N.

E-Layer Valley Again

Figure 9 also shows the *F2* high-density peaks around 250 km are pushing higher levels of ionization all the way down into the *E* layer. This shows that the

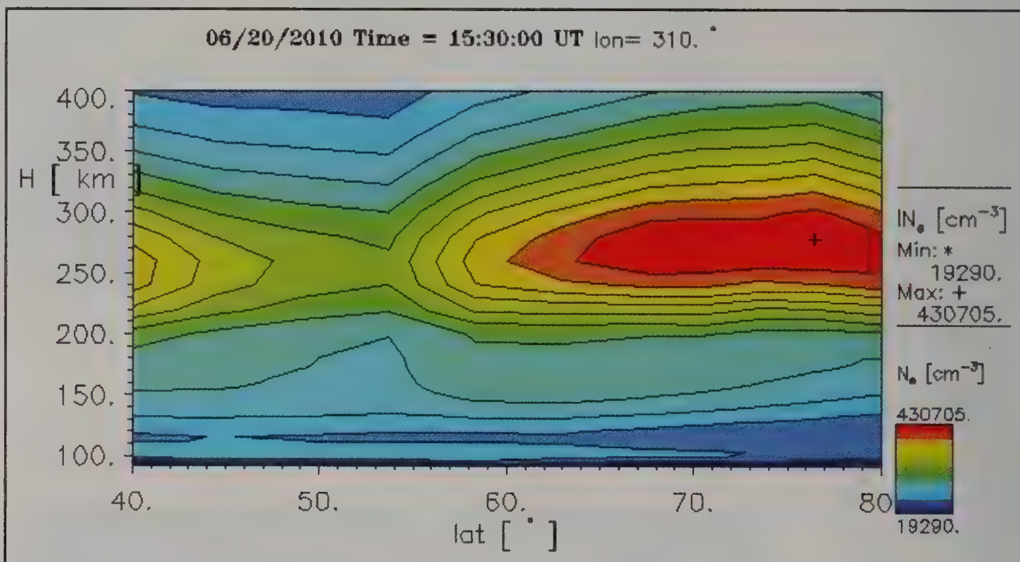


Figure 9. This is a vertical slice downward through the Figure 8 data, cut at 310E longitude near the path midpoint and its northernmost excursion. The feature leftward from 55N is leading to the main F2 lobe much farther south.

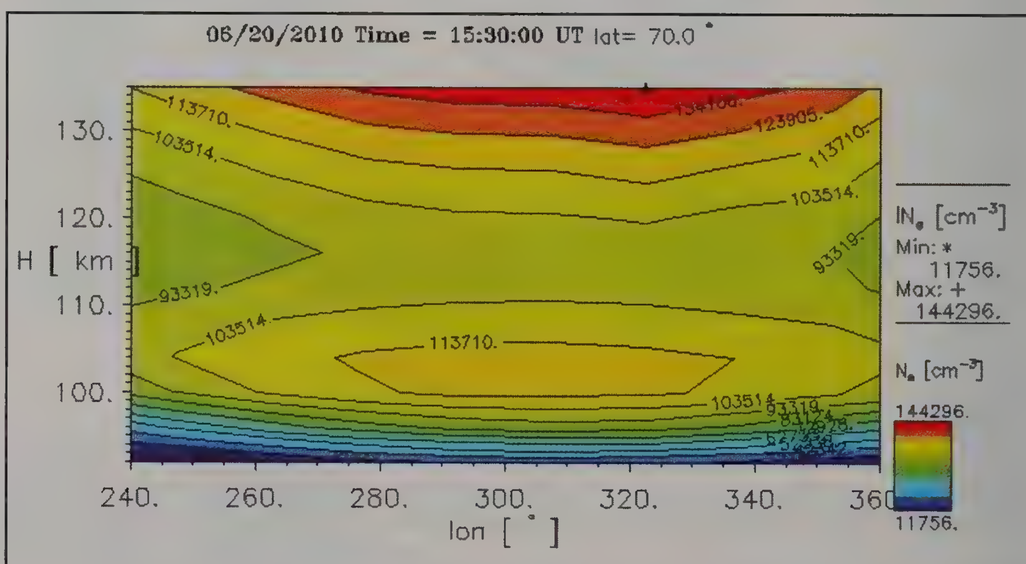
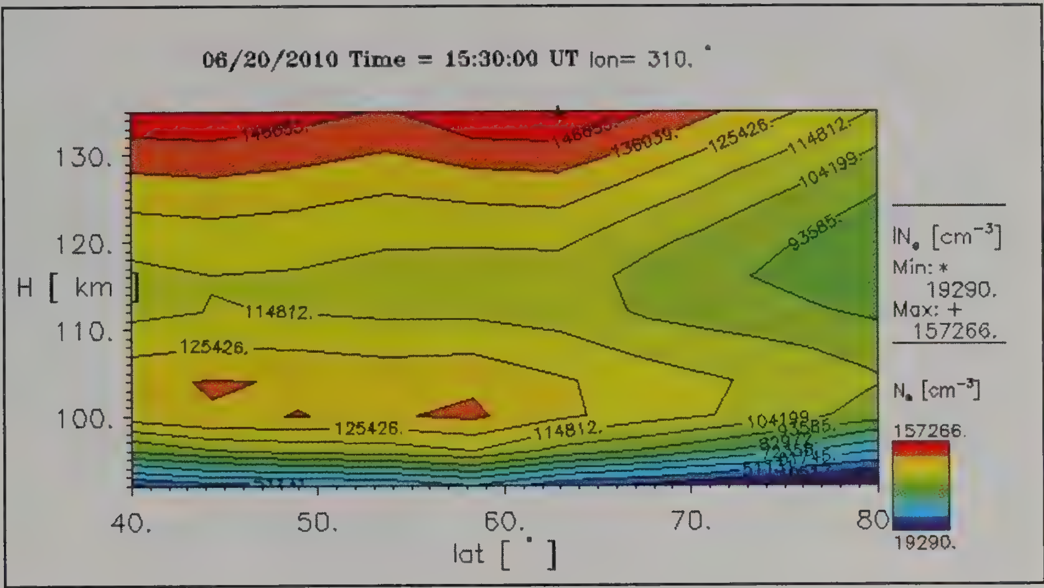


Figure 10. This is an east-west vertical slice through the figure 8 image at 70N latitude running most of the path, showing the E valley between 92 and 135 km.

Figure 11. This is a north-south slice through the E valley at the northernmost path point at about 310E. It shows that the north-south channel between the valley walls extends over 4,000 km.



upper ridge of the *E*-layer valley, in Figure 6, is just the long, low-side tail of the *F-layer* ionization.

Much of the east-west path was near latitude 70N. Figure 10 shows an east-west cut through only the *E-layer valley* portion of the ionosphere (92–135 km). The west end of the path is on the far right and the east end is on, or just past, the far left. Figure 11 shows a north-south cut along the mid-path longitude.

These show an *E*-layer reservoir peak near 103 km, then a valley, and starting about 115 km, there is a steadily increasing reservoir that, near 128 km, reaches the same N_e levels as the lower 103 km peak. The N_e values were on the order of $100{,}000/cm^{-3}$. These are normal summertime values corresponding to MUFs greater than 15 MHz.

The point is that these conditions existed in two places in the valley that were only 25 km apart in the vertical direction. The elevated *F2* conditions above the *E*-layer brought the upper side of the valley closer to the lower side, so that if wind shear was around, then the opportunity for both the upper and lower level to participate was enhanced. More importantly, this condition existed over much of the entire NA-EU path.

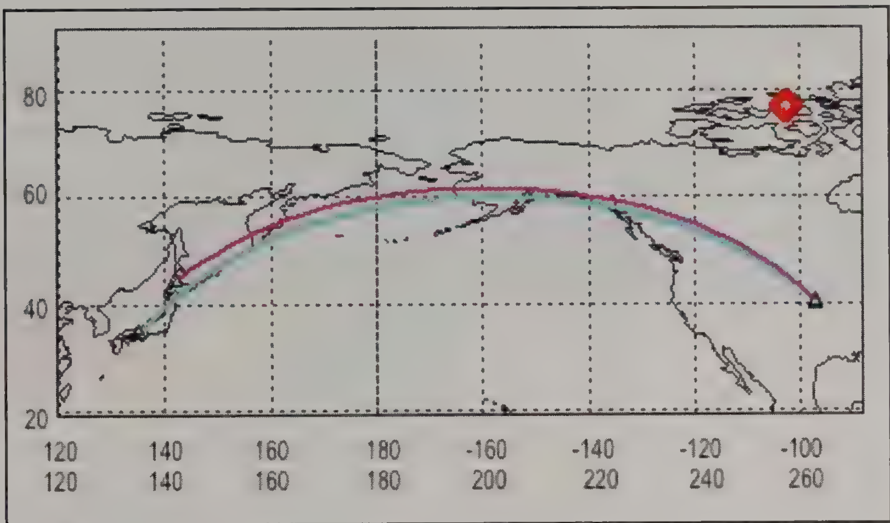


Figure 12. The 20 June 2010 JA–NA path extremes. The second longitude scale is in the "all east longitudes" notation used by USU-GAIM. The diamond near (80, –100) is the magnetic north pole.

JA–NA Path

Consider the conditions later that afternoon, looking now from NA toward JA. Figure 12 shows the path tracks. JA is a rather small target compared to all of EU. The paths are all very similar. The real difference is in how far south the paths go on the west end.

These paths don't go as far north as the EU paths. Some of those went nearly to 80N; here they all peak at about 60N. The other difference is the ionosphere, and the *F*-layer in particular. The persistent ridge-like *F2* peaks tend to track 10°–20° north and south of the magnetic equator. Due to the magnetic equator's inclination to the geographic equator, the angles of these ridges are somewhat different over the Pacific than over the Atlantic.

Arctic *F*-Layer Finger

Figure 13 (upper) shows that there is also a northern finger or ridge-like *F2* feature of locally enhanced ionization that seems disassociated with the persistent diurnal *F2* equatorial anomaly ionization maximum farther south. Unlike the NA-EU case, where the ridge overlaid almost the entire path, the Pacific ridge was south and west of the optimum location and was only associated with about the eastern half of the path.

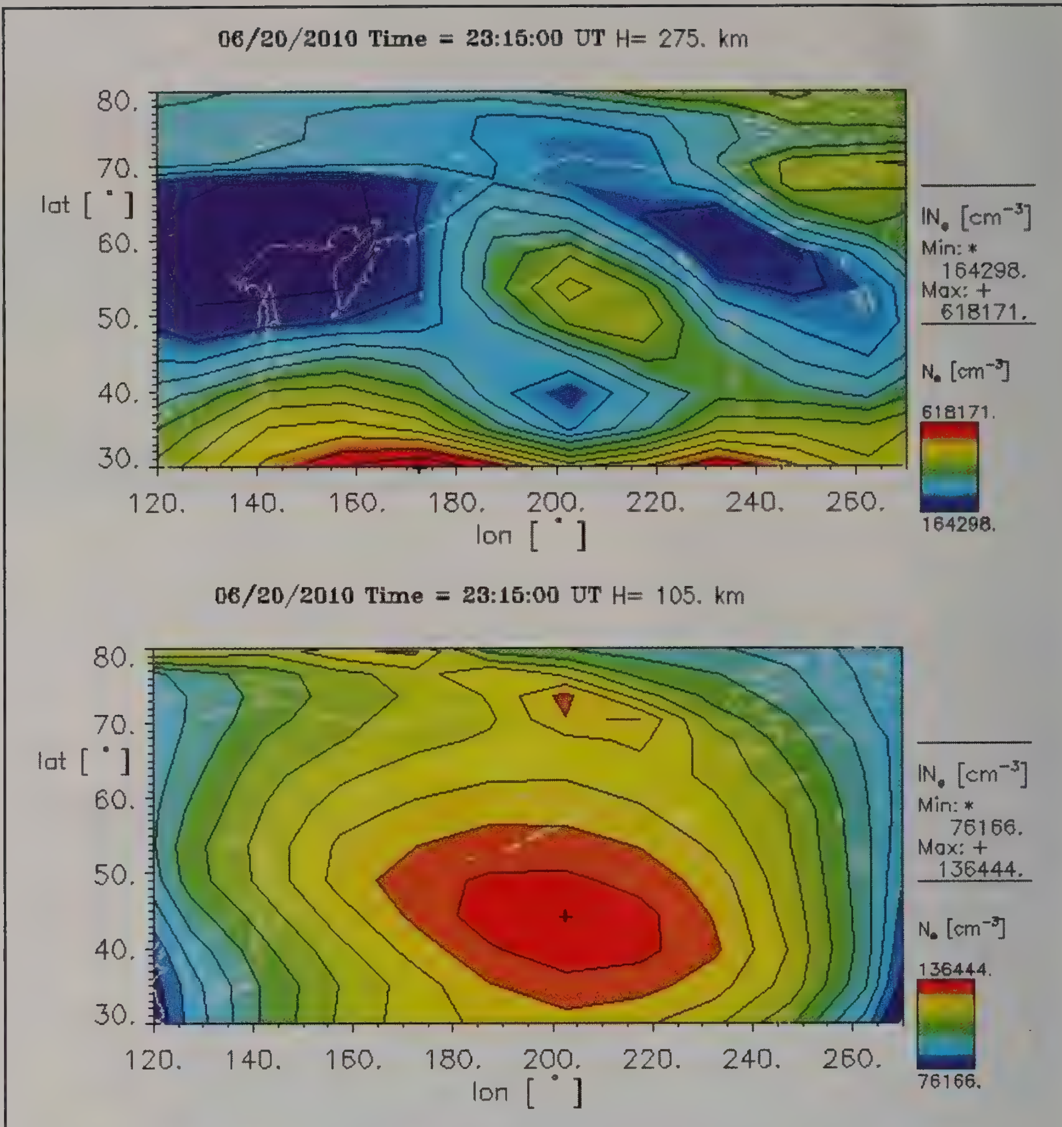
E-Layer Reservoir

Figure 13 (lower) shows that the shape of the normal *E*-layer ionization patch, which provides electrons for E_s, was shaped and centered in the northern Pacific in such a way that it produced a nearly constant of reservoir ionization on the path from western Canada until Japan.

Figure 14 indicates that despite the less than optimal alignment of the *F2* ridge, the *F*-layer ionization is apparently enhancing the upper edge of the *E* ionization valley.

Figure 15 is a close-up look at the east-west ionization along the path as seen at

Figure 13. Upper: At the opening midpoint time there is a small finger of F2 ionization in the vicinity of the first half of the path, south of KL7, although it is not optimally aligned. The main F2 region is seen building south of 30N. Lower: The underlying E-layer provides roughly equal amounts of N_e all along the path route. ⟶



55N. It will be noted from figure 12 that the path remains in that general latitude vicinity for quite some distance. It shows that, like the NA-EU case, there is a second region of enhanced *E*-layer ionization of the upper side of the valley that is only 10–15 km away. In the east-west direction this seems to provide a *channel* for the development of E_s both around 105 km and 125 km.

Finally, Figure 16 shows a north-south cut near the path midpoint, along latitude 190E. Here again, there is a resemblance to the NA-EU case in that it also shows that the north-south dimension of the channel region is quite extensive.

What Might Be Happening?

In order to address this question, the first step is to focus on defining the problem.

Why Shouldn't These Paths Work?

The initial concern was that the paths were so long that ordinary nE_s would be so attenuated by absorption and scattering after so many sky and ground encounters that there would not be enough signal left at the far end. This led to suggestions that tilted-layer chordal hops, chordal skip ducting between layers, or even progressive refraction during long passages through ionized regions might preserve the signal strength sufficiently.

Though arguments have been advanced, it has never been conclusively shown that it could *not* be nE_s. Nevertheless, some amazing propagation involving chordal modes (Kennedy 2003) have shown up in the *F*-layer, so it is reasonable to explore them in the *E*-layer.

There is another issue that has emerged in looking at this problem, and that is the matter of the long-known diurnal pattern of E_s, as discussed and diagramed in figures 1 and 2. What is seen is that paths such as JA–NA and NA–EU seem only to work consistently when the west-end early and east-end late probability peaks overlap. It suggests that something must be happening in the *middle* of the path to get over the hump.

Why Do They Work?

The answer to that is still unknown, but the limited work on this so far suggests a couple of hypotheses:

***F*-Layer Ionization Above and Channels in the *E*-Layer Valley Below**

Proceeding from the following observations:

- There is a known *E*-layer valley.

• E_s has been observed at least as high as 150 km, although it is rare that high

• Multiple E_s clouds between 100 km and about 135 km are more common

• Wind shears and vertical motions are all associated with the actual occurrence of E_s

• Though the diurnal E_s probability is lower at the path mid-point LST, the N_e reservoir is *maximum* there. Consider the following scenario:

It is plausible that E_s occurrences in a given region would be *enhanced* if the upper branch of the valley (fed by the *F*-layer) were squeezed down, physically closer, to the normal *E*-layer peak. If the two comparable levels of ionization were closer together, they could more easily participate in the available wind-shear engines at about the same time. This would lead to E_s clouds at, say, both 110 and 125 km, more or less simultaneously. If this were the case, then an important factor in these unusually long E_s links might be the positive influence of *having a well-ionized F region above the E-layer path.*

Only two openings have been examined in this detail as of now, so the statistics are very shaky. Nevertheless, there are a couple of apparent possibilities. In both the NA–EU and JA–NA openings, it appears that there was a *channeled E*-layer (not a single layer) at 105 km, about 25 km high, and 3,000–4,000 km wide that extended over much, or all, of the path. This could have led to a couple of things beyond just good conditions. All the "old" ideas are still on the table, perhaps even enhanced by the following conjectures:

Doubling the Odds. Much of the time E_s is *not* composed of a single sheet of intense ionization thousands of kilometers wide and long. Most E_s is made up a conglomeration of many, relatively small (up to 100 km horizontally), very thin clouds (tens of meters to a few kilometers vertically). Usually they are in motion, with the *E*-layer winds. As a result, E_s is usually porous; the signal not only hits the clouds and maybe skips, but also passes through the spaces in between them and keeps going up. If there were two (or three) sets of cloud producers, one above the other, the odds of getting an nE_s hop, or an ordinary chordal hop, would go up.

Bottomside–Topside Ducting. This physical configuration may also set up the between-layers ducting situation mentioned earlier. There is no way to tell for sure, but if bottom–top ducting were to happen, it would appear that this "channel" structure would be the ideal setting for it.

Discussion and Conclusions

The intention of this study was to look further into the east-west EWEE phenomenon to see how it behaved at different longitudes. In the Northern Hemisphere, it reviewed the well-known JA–NA path with more and new data, and added a comparable study of the NA–EU path. It would be useful to look at the EU–JA path, but at the time there were insufficient data available to do it justice. Perhaps this will be possible in the future.

One concern that has been raised in the past has been whether there could be an E_s path behaving according to mid-latitude "rules," if it involved latitudes as far north as 60N to 76N. It is common to talk about the transition from mid-latitude E_s to auroral E_s being at about 60N. However, this boundary actually has a wide range, depending on whether it is day or night and whether the geomagnetic field is quiet or active.

On the daytime side of the Earth the auroral oval is pushed rather far to the north, perhaps as far 80N. In the present case, the path midpoints were all on the daylight side. Moreover, during quiet geomagnetic times, such as have prevailed these last few years, the ionosphere south of the (northern) auroral circle has the same seasonal and diurnal rules at ordinary "mid-latitude" E_s (Hunsucker and Hargreaves, 2003). Thus, it may well be that the unusually long quiet Sun may have something to do with the amount of this propagation seen in recent years.

East-west EWEE propagation still has all the earmarks of an E_s propagation mode, or modes. The biggest clues are the fact that it is a local summer-season event, and it exhibits a quite rigid adherence to the diurnal E_s early-on-late effect. Almost without exception, the west-end stations are in their morning peak E_s probability window, while the east-end stations are in their afternoon-evening E_s probability window.

The maximum range of any path by EWEE probably will be constrained by the geographic limitations of the early-on-late overlap. In detail, this distance varies with station latitude. Lower latitudes have longer geographically possible early-on-late distances going out beyond 14,000 km. Typical maximum values at mid latitudes are in the neighborhood of 11,000 km.

Conclusions

The findings regarding EWEE from this more extended study are:

1. The evidence remains strong that these events are some form of E_s;
2. It is not clear whether some of these hops were chordal E_s modes;
3. Like the 2010 study, there is good evidence for nE_s playing a role for at least some of the hops;
4. The character of the JA–NA and NA–EU phenomena seem to be essentially the same;
5. F-layer enhancement of the E-layer valley may play a role.

A Final Caveat

Although the studied openings and paths appeared representative of other known similar events, the detailed comparison to the ionospheric model was restricted to this one 24-hour period. While the characteristics, such as the diurnal patterns, were essentially the same as many other observed events, one must be cautious about assuming that the conclusions here are generally valid until more samples are studied.

Acknowledgements

The USU-GAIM Model was developed by the GAIM team (R. W. Schunk, L. Scherliess, J. J. Sojka, D.C. Thompson, L. Zhu) at Utah State University.

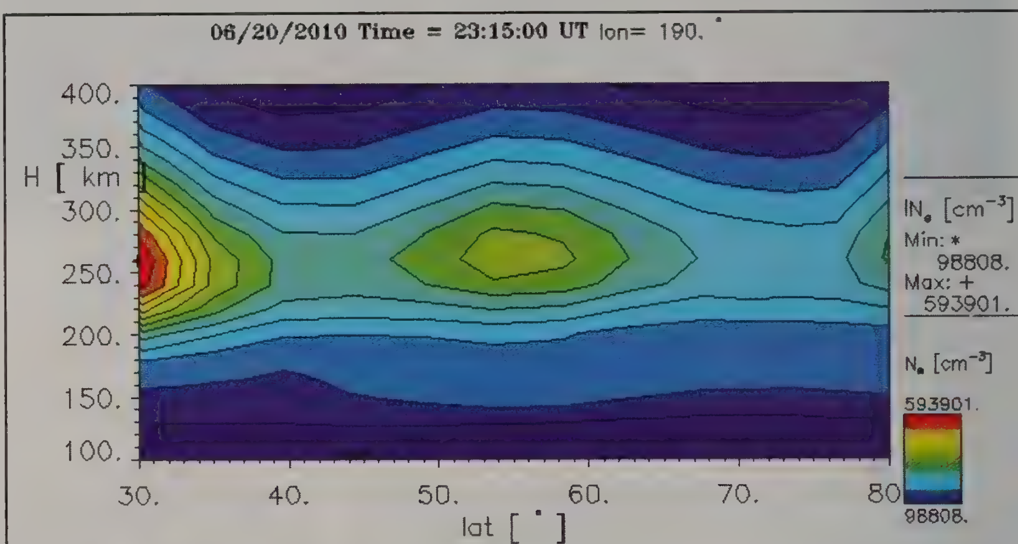


Figure 14. This is a downward slice through the figure 13 data at the path midpoint (190E) showing the F-layer enhancement due to the finger. Although the alignment with the path overall is a bit off, it seems to be projecting an enhancement toward the E-layer.

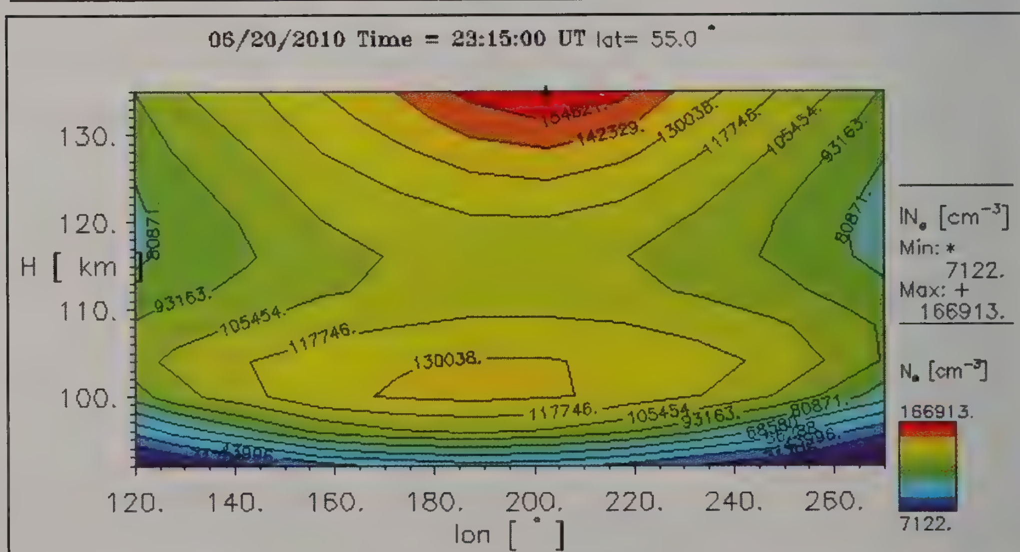
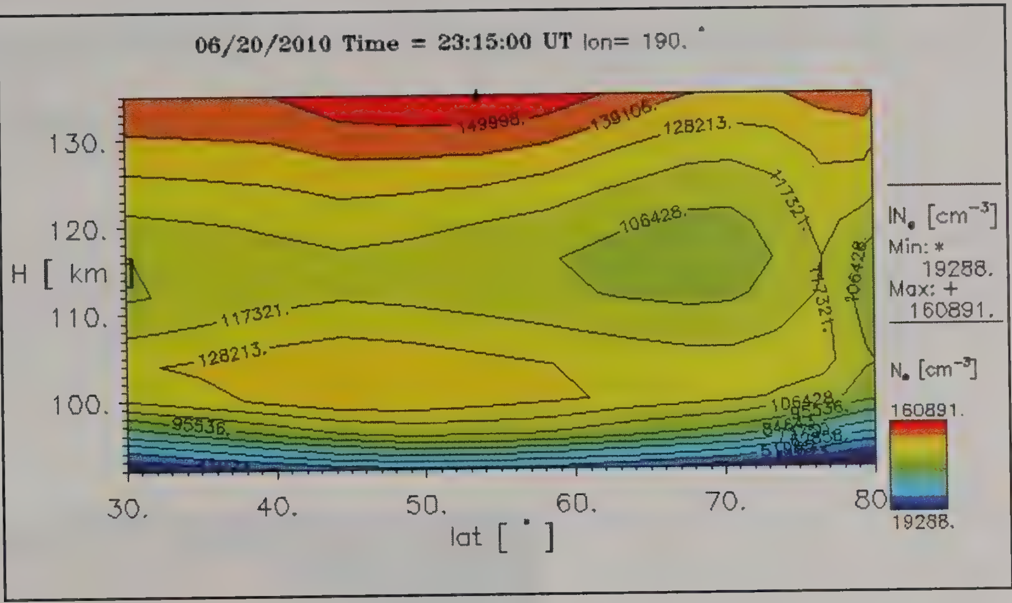


Figure 15. This is an east-west vertical slice through the figure 8 image at 55N latitude running most of the path, showing the E valley between 92 and 135 km.

Figure 16. This is a north-south slice through the E valley at the northernmost path point at about 190E. It shows that the north-south extent of the channel between the valley walls is over 3,000 km. ⟶



The authors wish thank the USU-GAIM team and the Community Coordinated Modeling Center group at the NASA Goddard Space Flight Center for sharing and running the ionospheric models presented here. They also thank Bob Culbertson, WA3YGQ, for assistance in identifying useful research papers regarding the link between meteors and E_S.

Note

1. The $2E_S$ was from W1 and W2 and 40°–50° east of the great-circle path to EU, probably not good indictors here.

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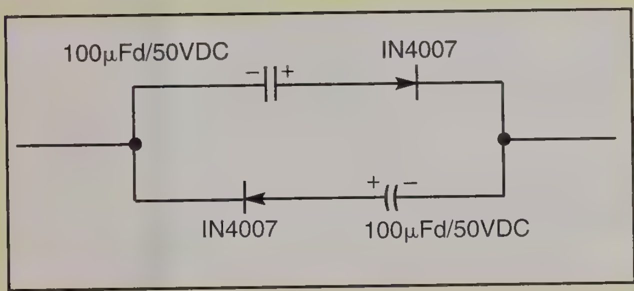

Correction:

"A Homebrew AZ/EL Rotor Controller"

By James Kocsis, WA9PYH
Summer 2011 *CQ VHF*

This article described an AZ-EL rotor controller system (see page 24 of the Summer 2011 issue). The author makes the following correction and clarification:

"One of the parts in the electronics is rather rare, and in the parts list I specified a part number and source. However, the part specified was a DC capacitor, which will not work, and the part needed is an AC capacitor for C4 and CS. The good news is that there is a simple and inexpensive way to build a substitute part. I checked the circuit shown here and it works perfectly. The parts are available from many sources places and at very low cost.

"The capacitance value should be twice the value of an AC capacitor and voltage rating greater than 1.414 times the RMS voltage in the circuit. Therefore, two of the following rated DC capacitors are needed: 100 μFd at 50 VDC."

Transcontinental F2 Propagation Returns to 6 Meters!

Cycle 24 is providing us with surprises, some resulting in 6-meter *F2* openings. Here WB2AMU tells of his experiences in 2011, plus predicts what may be in store for us in Cycle 24 and the activity he believes is headed our way.

By Ken Neubeck,* WB2AMU

Cycle 24 is proving to be an unpredictable solar cycle in terms of expectations. First there was an extended solar minimum of four years that preceded the cycle. Because of this, many solar scientists initially thought that Cycle 24 was going to be a very poor cycle in terms of sunspot count, thus dashing the hopes of amateur operators who were looking forward to the prospect of decent *F2* propagation activity on 10 meters, and perhaps even 6 meters. However, Cycle 24 is certainly providing its share of surprises, resulting in 6-meter *F2* openings.

2011 Cycle 24 Solar Activity

As reported in my article in the Fall 2011 edition of *CQ VHF* magazine, 6-meter *F2* propagation was present at the end of September when 9Y4VU and HC1HC were worked or heard by several stations in the northeast U.S. and Canada. This opening was important in that it meant Cycle 24 was not going to be a complete bust in terms of 6-meter *F2* activity. The only question remaining was whether Cycle 24 would have sufficient solar activity to allow the 6-meter band to see east-west *F2* sometime in 2011 or this year.

Beginning in January 2011, the sunspot count was consistently reaching double digits but still significantly below the 100-count threshold. However, the count started ramping up to the 100-count threshold by the fall of 2011 and the solar flux was increasing as well. Figure 1 shows the solar disk as of December 9, 2011, where the sunspot count reached 142 and the solar flux was 145.

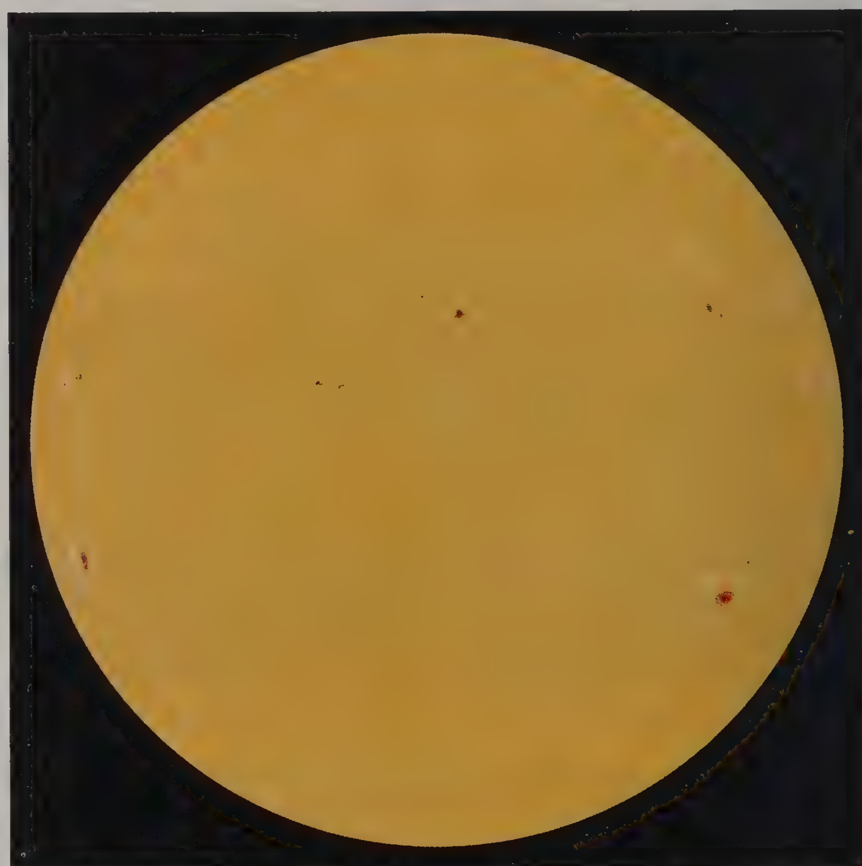

Figure 1. Solar disk, courtesy of SDO/HMI, shows the sun as of December 9, 2011, with a count of 142 and a corresponding solar flux value of 145. The sunspots are riding along on both sides of the solar equator.

During October and lasting into early November, I observed incredible conditions on 10 meters where the band would be open up to the evening hours. I could work stations in the Pacific and Asia from my location on Long Island, New York, using either a long wire or dipole. It seemed that the MUF was hitting close to 30 MHz in the path of the sun. I was hopeful that maybe there would be some *F2* activity occurring soon on 6 meters. Perhaps a major solar flare would occur and create some north-south *F2* paths on 6 meters after impact. Well, as it turned out, there were no significant flares that occurred in that manner.

Instead, I am happy to report that the ice has been broken for Cycle 24. East-west direction *F2* activity on 6 meters occurred when transcontinental North

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American 6-meter contacts were made in mid-November 2011 with stations working between the east coast of the U.S./Canada and the west coast of the U.S./Canada. This apparently is the result of increased 10-cm solar flux values reaching the 180 range beginning around November 7, at the same time that the sunspot count hit in near 150.

The first day of 6-meter *F2* that seemed to be the starting point was during the morning of November 13, when stations in the northeast U.S. and Canada heard the 6-meter beacons from Iceland and Greenland. However, and unfortunately, as far as can be determined no live stations were heard or worked.

A major amateur radio operator involved in these events was Steve, VE7SL. I had worked him from my Long Island QTH on 6 meters during the peak of the last *F2* cycle in November 2001, and a few times since then via two-hop sporadic-*E* during the summer months. On November 12, Steve worked NZ3M in Pennsylvania around 1800 UTC in what Steve described as a marginal *F2* opening. This may have been the first transcontinental North American opening on 6 meters for the new Cycle 24.

However, the real action began the next day, Sunday, November 14, when Steve worked 31 stations via *F2* from 1750 UTC to 1850 UTC. As Steve put it, the stations he worked were a real who's who of East Coast 6-meter operators. I was alerted to this opening by the ON4KST chat page, and I was fortunate to catch Steve during his string, despite some significant QSB on the signal. Table 1 shows Steve's log file in its entirety to illustrate several things regarding this particular *F2* opening.

Time (UTC)	Callsign	Grid
1750	N1BUG	FN55
1751	VE9AA	FN66
1754	W1IPL	FN54
1756	K1TOL	FN44
1757	VE1YX	FN74
1758	W1JR	FN42
1800	W1ECT	FN33
1800	K1CP	FN54
1803	VE3EN	FN25
1803	K1AC	FN43
1804	VA2WDQ	FN35
1806	K2ZD	FN21
1807	K1SIX	FN43
1808	K2MUB	FN21
1809	K1ZZ	FN31
1810	W3EP	FN31
1811	W1WV	FN22
1813	VE3MMQ	FN14
1813	WB2AMU	FN30
1815	VE3EK	FN03
1816	W1MU	FN53
1819	VA3NCD	FN03
1819	W1MM	FN42
1820	K2AXX	FN12
1823	N3DB	FM18
1824	K3TKJ	FM28
1828	K3XA	FM18
1829	VE2DLC	FN58
1830	VE1ZJ	EN95
1831	VY2ZM	FN86
1831	N3IQ	FM19

Table 1. VE7SL 6-meter QSOs on November 13, 2011. (All QSOs were CW except with K1TOL, SSB.)

First, when the opening started, it can be seen that the path was pretty narrow to the higher latitudes, with Steve initially only able to work Canadian stations and New England stations in Maine and New Hampshire. It can be seen that by 1800 UTC the opening started to "widen up" a bit, and stations in the lower part of New York State and Connecticut were worked. By 1823 UTC the opening spread down into the FM grid field of the Maryland and Delaware area, when N3DB and K3TKJ were able to be worked. Then the opening went "poof" at 1831 UTC.

A relative newcomer to 6 meters, Perry, VA7FC, from British Columbia, managed to catch some east coast stations during the *F2* opening while operating SSB. A number of stations did go on SSB but were affected by the severe QSB as the MUF danced up and down from the 40-MHz range up to 50 MHz.

In addition to working VE7SL, I managed to work two other stations on CW: N7NW (CN87) at 1827 UTC and K7CW (CN87) at 1818 UTC. Then the band dropped out. This particular opening exhibited the characteristics of a weak *F2* opening—only 30 minutes in duration and with significant QSB such that CW proved to be the most effective mode for making contacts.

Over the course of the next three days there were brief intervals of weak *F2* openings, where the MUF seemed to dance up and down above the 45-MHz ceiling. I heard NN7J (CN87) at 1900 UTC on November 15 for a few seconds, while a number of stations from the east coast worked K7CW and VE7DAY. On November 16 at 1830 UTC I heard K7CW briefly on my car's vertical antenna and then nothing else was heard. After that, no significant *F2* openings on 6 meters were reported by the 6-meter community.

A number of factors probably contributed to the *F2* opening occurring on 6 meters. First, the solar flux value reached sufficient levels to sustain an *F2* opening at an MUF of 50 MHz. Current *QST* "World Above 50 MHz" columnist, Jon Jones, NØJK, cites a previous "World Above 50 MHz" column by Emil Pocock, W3EP, where a minimum solar flux value of 175 was a value needed and anything above 200 was even better. Also, a quiet geomagnetic field is key, as that was what was observed during the entire month of November. Indeed, there were no aurora openings observed below the high latitudes on 6 meters, and the highest 3-hour *K* value that was recorded either planetary or at Boulder was 3 (unsettled). These two factors combined to produce the weak 6-meter *F2* openings that were observed from November 12 through 16.

As an additional observation, it was noted that the TEP (transequatorial propagation) openings on 6 meters between Argentina and Florida seemed to be less than expected during the October-November timeframe. TEP is the result of heavy ionization of the *F*-layer over the geomagnetic equator. However, it appears that it is aided significantly by solar events such as flares and CMEs (coronal mass ejections). The low *K*-index values during this time period are an indication of this.

Thus, while there was a north-south *F2* event observed in September, there really were not a lot of factors present to sustain north-south paths, either by *F2* or TEP. However, the solar-energy output measured by the 10.7-cm solar flux was sufficient to create *F2* events of the east-west variety, apparently well before any significant amount of north-south paths. This activity normally would have tracked with increased solar flares and CMEs. Based on my experience during Cycle 23, I thought that for the beginning of Cycle 24, I would work stations in Central America and the northern part of South America well before I could work the U.S. west coast or into Europe. It appears that things are different this time around.

I think that this situation also plays to the fact that we are dealing with a different beast with Cycle 24 as compared to previous cycles. I believe that there is a tendency to depend too much on previ-

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	113.0	116.9	120.0	**120.9**	119.0	118.8	119.8	118.7	116.3	114.5	112.7	112.1
2001	108.7	104.0	104.8	107.5	108.6	109.8	111.7	113.6	114.1	114.0	**115.5**	114.6
2002	113.4	114.6	113.3	110.5	108.8	106.2	102.7	98.7	94.6	90.5	85.3	82.1
2003	81.0	78.6	74.2	70.4	67.9	65.3	62.1	60.3	59.8	58.4	57.0	55.0
2004	52.1	49.4	47.2	45.6	43.9	41.7	40.2	39.3	37.6	35.9	35.4	35.2
2005	34.6	34.0	33.6	31.7	28.9	28.8	29.1	27.5	25.9	25.6	25.0	23.0
2006	20.8	18.7	17.4	17.1	17.4	16.4	15.3	15.6	15.6	14.2	12.7	12.1
2007	12.0	11.6	10.8	9.9	8.7	7.7	7.0	6.1	5.9	6.1	5.7	5.0
2008	4.2	3.6	3.3	3.3	3.5	3.2	2.7	2.6	2.2	1.8	1.7	1.7
2009	1.8	1.9	2.0	2.2	2.3	2.7	3.6	4.8	6.1	7.0	7.5	8.2
2010	9.2	10.6	12.3	13.9	15.4	16.3	16.7	17.4	19.6	23.2	26.5	28.9
2011	31.0	33.5	36.9	41.8	47.6	53.0e	57.4e	61.3e	63.9e	65.7e	68.3e	71.8e

Note: The letter "e" after the value indicates estimated value that will be recalculated as more data is collected.

Table 2. Smoothed sunspot number by year. (Issued 12/1/11 by the Australian Government Radio and Space Services)

ous observations to construct predictions for each new solar cycle. Remember that the start of Cycle 24 was so much different from previous cycles, with the prolonged solar minimum that was observed from 2006 through 2010.

The Tad Cook, K7RA, weekly propagation report for the first week of November (ARLP044), published by the ARRL, stated that because of increasing solar activity for the third consecutive month, NASA had to revise its prediction for the peak of Cycle 24, with each time estimating higher intensity and changing the projection for the month the cycle is expected to peak. The K7RA report states:

> On September 1, they moved the expected peak from June 2013 to May 2013, and the smoothed sunspot number from 69 to 70. At one time they were predicting a maximum nearly the same as the 1907 maximum of Cycle19, 64.2, but of course recent predictions are substantially above that value. NASA noted that the current cycle would still be the smallest in the past hundred years.
>
> A month later on October 3 they upped it again, with the maximum smoothed sunspot number jumping from 70 to 77, and the peak moving again, this time from May to April 2013. But at this level, it would still be the weakest cycle in 100 years.
>
> This time on November 2 their prediction made a big jump, from 77 to 89, but with the peak moving back out, this time from April to May 2013. This makes the cycle slightly bigger and longer, and instead of 100 years, it is the smallest solar cycle in over 80 years.
>
> The latest prediction from NOAA and USAF for the near term has solar flux at 165 on November 4-10, 160 on November 11, and 150 on November 12–15, 160 on November 16, and peaking again at 165 on November 17–18, then falling to 155, 145, 140 and 130 on November 19–22.
>
> It is noted that solar flux values of over 180 were recorded for the three-day period of November 7 through the 9, dropping to below 170 by November 12. Thus, the actual count was about 15 higher than predicted for the period up to November 10.

Indeed, many of us remember the dire predictions that were made as recently as the year 2009 by a panel of solar experts that predicted that solar Cycle 24 would peak in May 2013 with daily sunspot numbers of 90. It is noted that a daily sunspot count of 208 was recorded by NOAA on November 9. If the original prediction was to prove true, solar Cycle 24 would be the weakest cycle since number 16, which peaked at 78 daily sunspots in 1928 and the ninth weakest since the 1750s, when numbered cycles began. The smoothed sunspot number (SSN) value was predicted by the experts in 2009 to only reach a SSN of 70 for this cycle! Well, as of December (when this article was written) the estimated smoothed sunspot number is already at 72, so it would seem that all bets are off with regards to pessimistic solar-cycle predictions.

The Australian Government's IPS Radio and space service report issued on December 1 shows the smoothed sunspot numbers as provided in Table 2. In this table it can be seen that Cycle 24 has progressed rapidly beginning in early 2010 when the SSN value reached double figures and rapidly rose during 2011. Two cells are highlighted by me in this table—April 2000, which shows the first peak of 120.9 for Cycle 23, and November 2001, which shows the second peak of 115.5 of Cycle 23. Many veteran operators will remember that while 2000 was a decent year for 6-meter activity, it was not until the fall of 2001 that 6-meter *F2* activity was a daily event, with solar flux values exceeding 200 on a daily basis.

Predictions and Activity

I never could understand why in making their predictions scientists do not adequately address the double-hump configuration of the solar cycle. While it is recognized that the first peak from Cycle 23 was important, the reality is that the second peak was the most important to radio amateurs, as it meant sustained *F2* activity on a daily basis on both the 10-meter and 6-meter bands. It was by the time of the second peak that the solar-flux value caught up with the sunspot count, where on a daily basis both values exceeded 200.

I really think that while the experts may try their best to predict the sun's behavior and create models through the use of computer simulation and the crunching of data collected from previous sunspot cycles, I feel that the sun is a dynamic and somewhat temperamental object (behaves like a human being?) that defies easy description and modeling. One reason that I feel this way is that the Maunder Minimum, the 70-year drought of sunspots from 1645 through 1715, seemed to have been an unusual event that defied predictions, particularly since there has not been a reccurrence in the 350-year period since then. I believe the sun is something that mankind does not fully understand.

This drives me to the point that maybe Cycle 24 will be a decent cycle after all in terms of observing 6-meter *F2* activity. With the appearance of sporadic activity during the fall of 2011, I suspect that the solar sunspot count and solar flux

value will continue to climb upward such that the fall of 2012 may be significant in terms of 6-meter *F2* activity. I am not sure if 2012 will be a year during which daily 6-meter *F2* activity will be observed during the fall, or if 2013 will be the year, since 2013 would fit into the situation of a double peak. Furthermore, if solar flare and CME activity remain lower than expected, the *F2* that appears may be more on the order of east-west paths with not too much in the way of north-south paths. Thus, Cycle 24 may be truly unique, defying all efforts to characterize it by models constructed by solar scientists. Hams may be on the forefront of observing a very unusual solar cycle!

However, there are suggestions by some ham operators that maybe we have seen the best of Cycle 24 during the modest November *F2* openings on 6 meters. It would be easy to go along with this assessment, given the previously dire predictions by the solar scientists. However, I point out that the solar activity has made tremendous strides in a short amount of time. I recall that while operating strictly 10 meters during the 2011 ARRL DX CW contest at the end of February, I did not hear any European stations at all. The *F2* skip on that band was strictly north-south paths where I was working into Argentina and Brazil. By mid-October into December, Europeans were able to be worked on a daily basis on the 10-meter band, and to top it off, there had been limited numbers of radio blackouts during minimal solar-flare activity.

Want more proof on the drastic changes to the HF band? During the December 2010 ARRL 10 Meter contest, I worked only about five DX stations. In the recent December 2011 event, I worked over 150 DX stations, with 75 percent of them from Europe. This is about as drastic a change as I have ever observed during my 35 years of operating in this event. From previous cycles that climbed up, I would see a handful of European stations able to be heard on the band, not in the hundreds like I saw this year!

The point that I am making is that in a matter of just eight months, the MUF has climbed rapidly, and there would be no reason to suspect that the cycle is just going to stop short at this time. There is most likely a sufficient amount of positive movement that will carry into 2012, with more 6-meter *F2* activity likely.

In going back to my notes that I took at the beginning of Cycle 23, I noted that in many ways the observations on 6 and 10 meters during 1999 seemed to have some similarities with what was observed during 2011. In 1999, I observed a north-south *F2* event on October 23 when I worked HC5K in the afternoon, almost tracking with the late September opening of 2011, when I heard 9Y9VU and HC1HC. Then there was another north-south *F2* 6-meter event on November 11, 1999, when I worked EH8BPC, and finally the first east-west transcontinental event on 6 meters in the evening of December 19, 1999, when I worked AA7CQ, K8KV, and WX7R in the CN87 and CN85 grid fields.

The 2011 ARRL 10 Meter contest was an upgrade from the previous year, with Europeans easily being worked from the northeast U.S. in the morning on both days. Thus, 1999 and 2011 compare pretty well in terms of amateur radio observations collected. Aurora activity was present during 1999, but none was observed in November or December of that year, indicating lower geomagnetic activity, similar to what was being observed in December 2011.

It would appear that we are dealing with a 12-year spread between similar points in the cycles Cycle 23 and Cycle 24. This would make sense, because the solar minimum was an extra-long process, probably one year more than normal. Thus, if we use the rough comparison between the two cycles, the fall of 2012 will see occasional *F2* events on 6 meters. However, most likely, near-regular 6-meter *F2* activity will appear in the fall of 2013, possibly at the time when a second peak occurs. I realize that this is a kind of crude way of making a guess when things might happen. However, given the lack of accurate models, amateur radio observations on the 10- and 6-meter bands actually may provide a better means of determining when things will happen.

"Heads Up"

With Cycle 24, this time around 6-meter operators have the benefit of improved internet monitoring. In addition to the 10-meter liaison frequency of 28.885 MHz, chat pages such as the ON4KST site will allow operators to quickly move into action. Also, the Spaceweather.com site (http://www.spaceweather.com) conducted by NOAA will allow a "heads up" for operators with regard to current sunspot count and solar flux values.

It is about one complete solar rotation (approximately 27 days) at the time of this writing, which are the first and second weeks of December. Using observations from past experience, the sunspot group with the high solar flux values that impacted the Earth beginning on November 13 should be in position.

Some Techniques for Building Ultra-Low-Noise Preamps Part 1

The following is the first part of a series of articles in which WA2ODO describes his insights into his success in building ultra-low noise preamps.

By Pete Manfre,* WA2ODO

Many have asked how I am able to obtain such low noise figures with my design of LNAs. My standard answer is usually "with smoke and mirrors." However, in fact, it is somewhat simple. Simple, yes. Easy, no. Simple, yes—after you do all the research and experimentation testing and sorting parts as per their noise figures, which is the "easy, no" part.

The best I can explain it is that certain rules must be strictly adhered to. The major rule I advise is the attention to the slightest detail. For example, never solder anything unless it first is making good electrical contact. Solder is a holder, not a conductor (at best a conductor that does add a little noise). I always use solder that has a percentage of silver in it, as I find it quieter. An additional rule is that all parts generate noise. Therefore, use as few parts as possible to accomplish what you want without circuit-performance compromise.

Not all parts are created equal in the eyes of the noise-figure meter. Two identical values of parts but of different manufacturers generate different noise. Therefore, experiment and pick the best for your purpose. The most expensive is not always the best. This goes for FETs, caps, and resistors. It very much applies to piston capacitors, too, with sapphire being the quietest and ceramic being a close second.

Component layout can have a considerable effect on the noise figure and gain, as does the choice of connectors. Certain connectors are very noisy. Preamplifier enclosures also have a varying effect on the noise figure due to internal self-resonances. Enclosures are cavities, which can impact the noise figure for good or bad.

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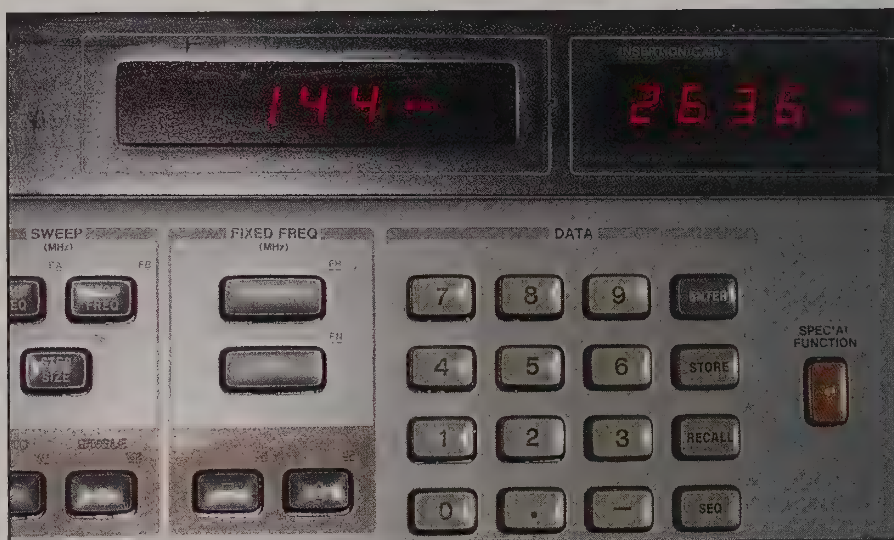

Image 1. These results are possible with attention to details and the use of low-noise parts.

With respect to the "front end"—the input of the circuit—there is an ideal Q that will yield the lowest noise figure. Too low or too high and the noise figure goes up. All coils on the front end should be silver-plated. (I rhodium-plate mine on top of the silver to prevent tarnishing.) This tarnishing affects the noise figure adversely over time, so this application of rhodium prevents degradation. I have tried many sizes and materials for the coils. The best I have found is not the biggest or smallest, and 18g to 14g seems to yield the best results.

As for materials, the best seems to be silvered copper. I have tried pure copper, gold-plated copper, and sterling—all inferior to silver plating. The best dielectric material for PCBs I have found is air. Therefore, hand-build all preamps with components above the board, especially on the input side of the schematic. Minimize losses wherever you can.

Not all FETs are created equal—even the same type, brand, and batch. Some are just plain better than others. Sometimes you might have to waste a few to get a "hot one." And since they are not all the same, be sure that you can adjust the source currents and drain voltages independently to squeeze out the best you can for that individual device. Additionally, and very important, just because the manufacturer has cut-off frequencies does not mean the device will not work below or above those frequencies. In most cases, it performs better but the stability suffers (K below 1). Therefore, an additional problem needs to be addressed: making it stable if possible. Sometimes this is harder than obtaining a lower noise figure.

Once I find a specific part that has an exceptionally low "noise additive" (as I call it), and have done my homework and proved it through multiple builds and

Imnage 2. This is also attainable with attention to details, details, details.

substitutions, then I try to buy a sufficient quantity of that identical part to last a lifetime. A perfect example is that not all bypass capacitors are created equal. I have found some that are exceptionally nice and quiet also, so I bought several thousand of them because they were priced ultra-low. I will not have to search for those any further. I did the same with the FETs. I still have 13,000 remaining, which should last a lifetime or two (or three or a hundred). The point is I will not have to go through this exhaustive testing and searching for them again. It does not mean, however, that I stop looking for better. Rather, I do it with less vigor.

Most importantly, do not attempt to make a super ultra LNA without a good calibrated noise-figure meter. Some examples of good meters for the purpose and also affordable to amateurs are the HP-8970A and B, HP-8970S, and the

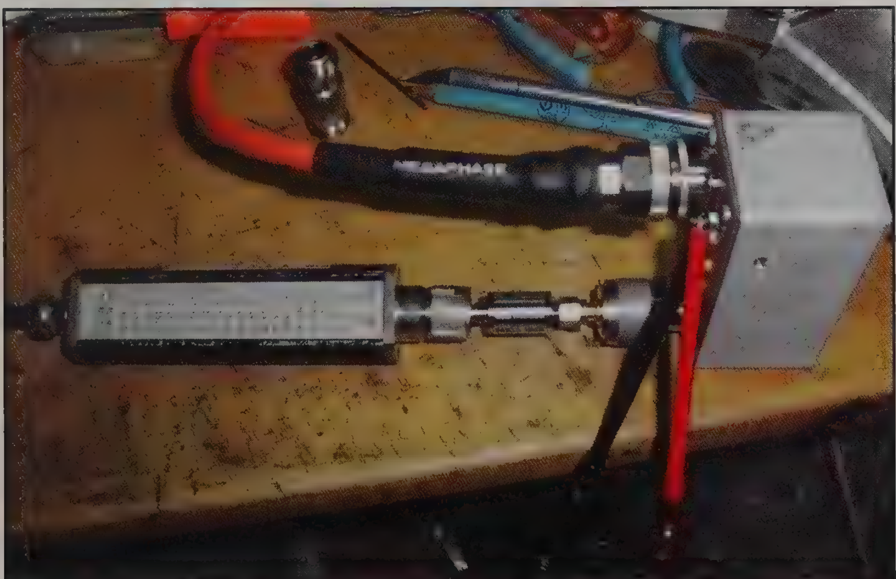

Image 3. Notice the calulated noise source and 10 dB attenuator—a must only for accuracy, but not necessary for tuning and comparing several preamps.

Image 4. My travel case of conference preamps for entry into noise-figure-measuring contests. Notice the many bands and layouts within each band.

2075 series by Ailtech/Eaton/Maury. Almost any noise source will work, but it must be stable and you must know the excessive noise ratio (ENR). When testing and adjusting LNAs, never use an ENR higher than 5 dB. You might need to add a calibrated 10-dB attenuator to your 15-dB ENR noise source (readjusting the ENR table to reflect this). Good noise sources are made by HP, Noisecom, Ailtech, Eaton, Maury, MSC, Micronetics, etc.

Having a vector noise analyzer (VNA) handy is great for the initial development, but not as necessary as the noise-figure meter to squeeze out every last part of a dB noise figure. A hundredth here and a hundredth there starts to add up.

Summary

I have not given many specifics here, as I cannot, because obtaining the same exact parts and materials is not always possible. The rule is experiment and try.

This has been a never-ending project for me. My first 144-MHz preamp was in the 0.5-dB range. I just kept trying ideas and different brands of parts until I found the proper combination for my design.

There are hundreds of well-designed and easy-to-build schematics all over the web. My design is nothing special. It is my choice of parts and details that allows obtaining the ultra-low noise figures. Naturally, being a retired watchmaker and jeweler (as well as a retired electronics instructor) certainly does not hurt in working with very small and delicate parts and being cognizant of the details. However, with practice you can be proficient. "Practice makes perfect."

To duplicate one of my current preamps would take about $78± (labor not included), using newly ordered components. I sell the preamps for $85 and use the profit to supply free preamps to legitimate EME DXpeditions and to give them as gifts at conferences.

You have probably noticed the absence of any specifics for building any of my preamps. The main reason, in my opinion, is that you must learn to walk before you learn to run. Therefore, almost every preamp design that has been published can be made to obtain close to what I obtain using the correct and quiet parts and proper techniques. Conversely, you can take my schematic and having built it without following basic techniques; it will be no better than any other generic preamp. In subsequent articles I will give additional hints and specifics for obtaining lower noise figures, but for now try these with what you have and see what can be accomplished.

Hopefully, I will be attending the 2012 EME conference in Cambridge, England. I will look forward to meeting several of you there to further discuss this heated preamp topic. I will be bringing preamps to sell, as well as FETs for sale and some of both as dinner prizes.

One-KW Solid State Amplifier for 144 MHz Using the NXP BLF578 Push-pull Transistor

This paper originally appeared in the *Proceedings* of the Microwave Update 2011 and 37th Annual Easter VHF/UHF Conference of the Eastern VHF/UHF Society. It has been slightly updated for its appearance here in *CQ VHF* magazine.

By Fred Stefanik,* N1DPM

This article describes a 1-kW solid -state field-effect transistor (FET) amplifier pallet for 144 MHz based on the NXP BLF578 LDMOS FET. The original basis for this amplifier can be referenced in the NXP application note AN10800 available on its website: <http://www.nxp.com/search?pcon%5B%5D=Application+note&rows=10&type=keyword&q=an10800&page=1&tab=All&filterChanged=pcon%5B%5D>.

This application note describes using it for a 1-kW broadcast amplifier in the 88-MHz to 108-MHz FM band. Note: It is necessary to download the application note because it is referred to in the text below and it contains the parts list for the bias circuit that is common with this amplifier.

There are four basic parts to the pallet: the input circuit, the output circuit, DC drain power feed, and the temperature-compensated bias circuit.

The Input Circuit

The input circuit (see figure 1) consists of a coaxial balun used to take the 50-ohm unbalanced input RF and turn it into a balanced 25-ohm source. Each side of the output of this balun then feeds to a 4:1 coaxial balanced transformer system to feed the gates of the FET. The balun is made of an 11-inch length of 50-ohm 0.085 diameter coaxial cable. The output side then feeds through two DC-blocking capacitors and onto the 4:1 transformer.

Two 2.5-inch lengths of 18-ohm, 0.062-diameter semi-rigid coaxial cable form the transformer section. Each of these coaxial lines are inserted into a ferrite aperture core (Amidon BN-61-202: <http://www.amidoncorp.com/items/63>) to increase the inductance of the outer conductor. This increase thus lowers the usable frequency of the transformer for its given length. These ferrites may not be necessary on 144 MHz. However, I started with the FM broadcast circuit. There are a few chip capacitors used for optimizing the input circuit on 144 MHz. See the schematic values.

The Output Circuit

The output circuit (see figure 2) is essentially a duplication of the input circuit in reverse. Starting at the FET drain connections, the FET feeds a 1:4 coaxial balanced transformer system. This transformer section is made with two 5.25-inch long 25-ohm Teflon® dielectric flexible coax. From the output of the transformers, the RF is fed through DC blocking capacitors and into an 11-inch long piece of 50-ohm Teflon® coax (RG142) to act as an output balun to get back to 50 ohms unbalanced.

Also, at the output of the transformers on the balun side of the blocking capacitors are two 15-pF capacitors to ground. These capacitors match the impedance between the transformer output and the balun input. At the output of the balun there is a 4.625-inch long stub of Teflon® coax used to reduce the third harmonic energy. The reason for these capacitors is that it forms a matching circuit (L-network) between the balun coax and the capacitors to ground.

DC Drain Power Feed

The DC is fed to the drains of the FET through the 1:4 output transformer system. In the NXP application note, the output side of the transformer system has the coax shields decoupled to ground via a broad range of chip capacitors. My amplifier started out this way. I had an "incident" while bench testing for an extended period at full output where at least one of these capacitors failed.

When one failed, between the DC power and the RF power available, it burned the capacitors to ash and did some irreparable damage to the PC board. I did some investigation and there

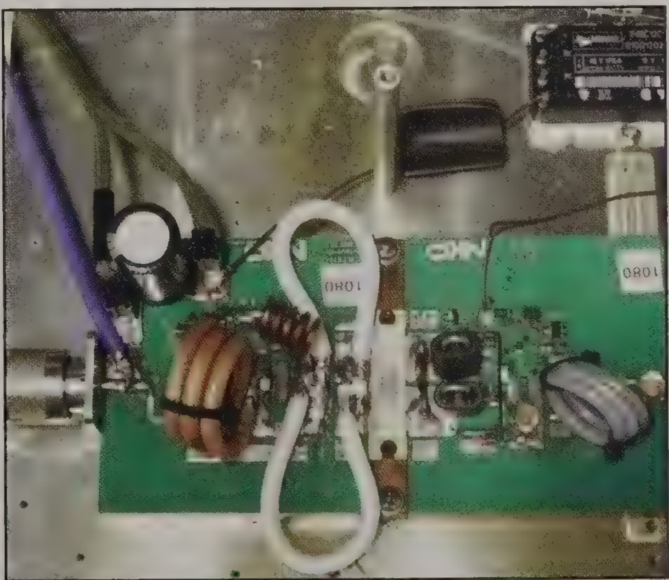

Photo 1. The completed amplifier. Note the blue 4.625-inch long stub of Teflon® coax on the left side of the photo. It is used to reduce the third harmonic energy. (Photos courtesy the author)

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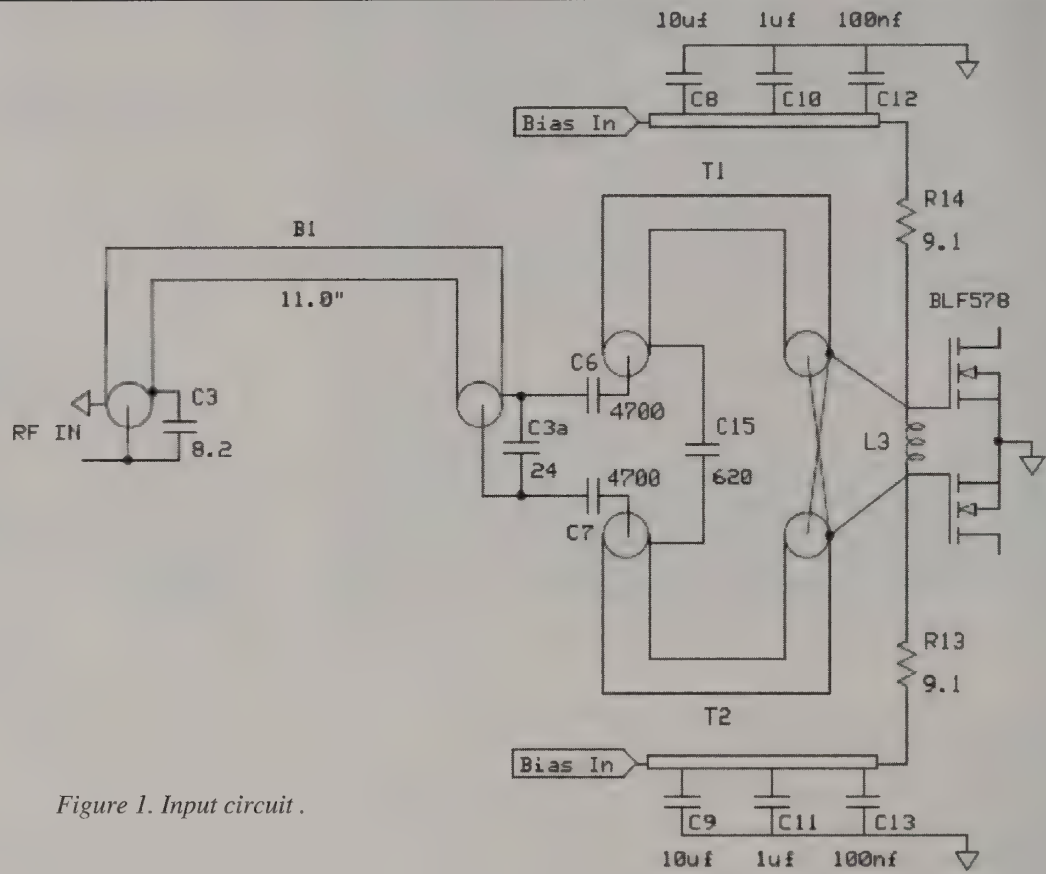

Figure 1. Input circuit .

seems to be two ways of dealing with this point in this type of circuit. The first is to decouple this point to ground with capacitors and feed this point through a choke that is again decoupled on the DC side.

The second method simply removes the capacitors that I had burned up. I removed them but not in the neatest way, so I proceeded to operate the amplifier without them and saw essentially no operational or performance difference. This point theoretically should be RF cold anyway if—and here is the big *if*—the inductance in the shield of these transformer coaxes is high enough to isolate this point from the FET drains.

Photo 2. The opposite end of the stub showing the open (or non-) connection.

The DC is fed to this point through a coil that is five turns of #12AWG copper wire. The DC side of this coil is bypassed with a set of capacitors forming a broadband bypass to decouple both RF and modulation components.

The Bias Circuit

A temperature-compensated bias circuit (see figure 3) is used and comprises the following:

An 8-V voltage regulator supplies the bias circuit. The temperature sensor (Q2) must be mounted in good thermal contact with the RF FET. The quiescent current is set using a potentiometer (R1). The RF FET gate voltage correction is approximately –4.8 mV/°C to –5.0 mV/°C.

The –2.2 mV/°C at its base is generated by Q2. This is then multiplied up by the R11-to-R12 ratio for a temperature slope (i.e., approximately 15 mV/°C). The multiplication function provided by the transistor is the reason it is used rather than a diode. A portion of the –15 mV/°C is summed into the potentiometer (R1).

Resistor R4 sets the amount of temperature compensation. The ideal value proved to be 2 k ohms. The values of R9, R13, and R14 are not important for temperature compensation. However, they are used for baseband stability and to improve intermod distortion (IMD) asymmetry at lower power levels.

Construction

The FET will have to dissipate over 300 watts in operation. This is a small physical area to sink this amount of heat away from the part. Because of this problem, it is a necessity to use a copper heat spreader/base plate for the amplifier. Copper is a far better thermal conductor than aluminum or brass.

The PC boards are soldered to the copper spreader. They could also be screwed in place; however if any oxidation forms after years of use, the performance may suffer. Soldering the boards einsures a good electrical bond that will last a lifetime.

As you build the amplifier I suggest building the bias circuit first. The reason for this is you can test it and know that it works properly before putting the expensive FET in place.

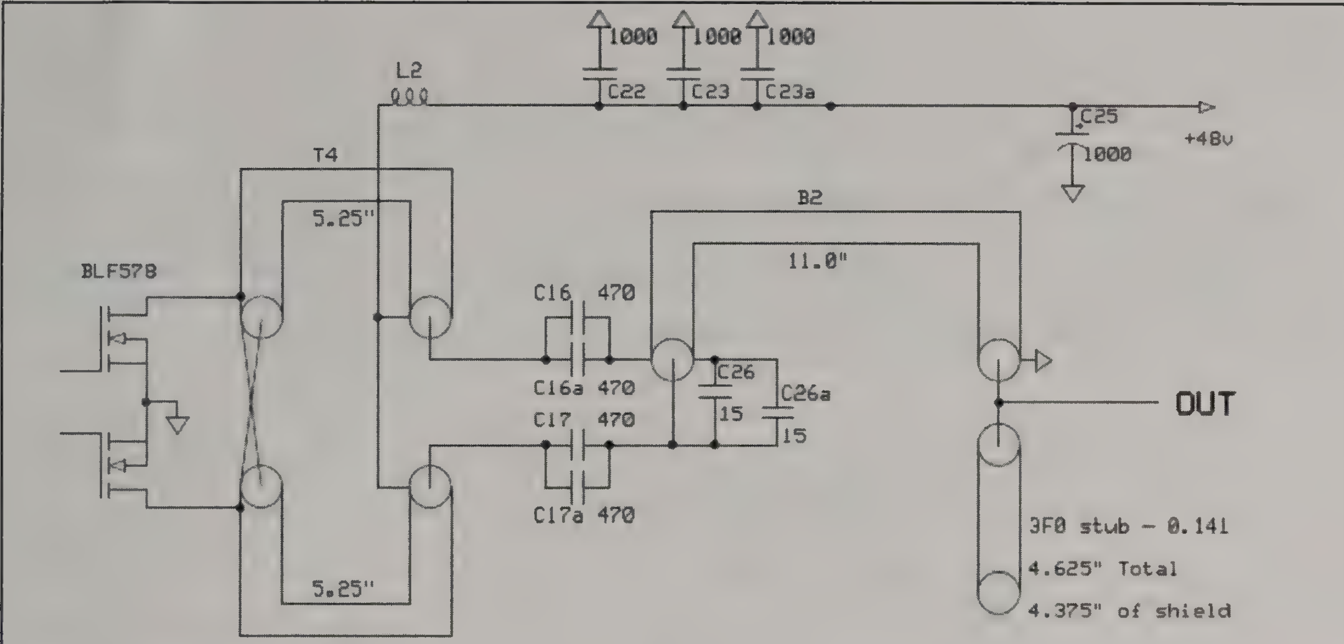

Figure 2. Output circuit.

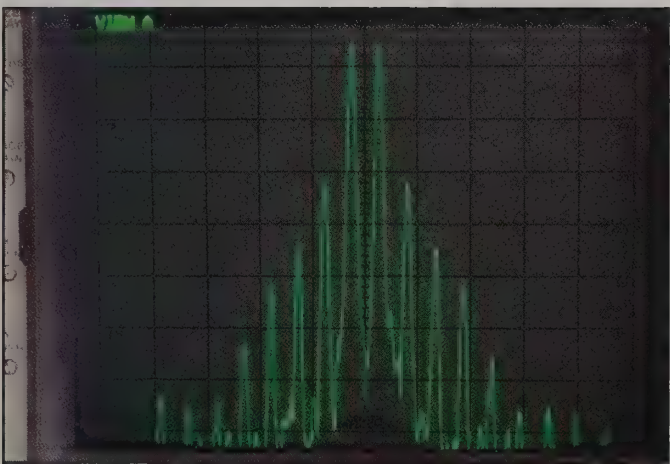

Photo 3. Two-tone test at 1 kW PEP: IMD3 = –32 dB; IMD5 = –44 dB; IMD7 = –52 dB; and IMD9 = –66 dB.

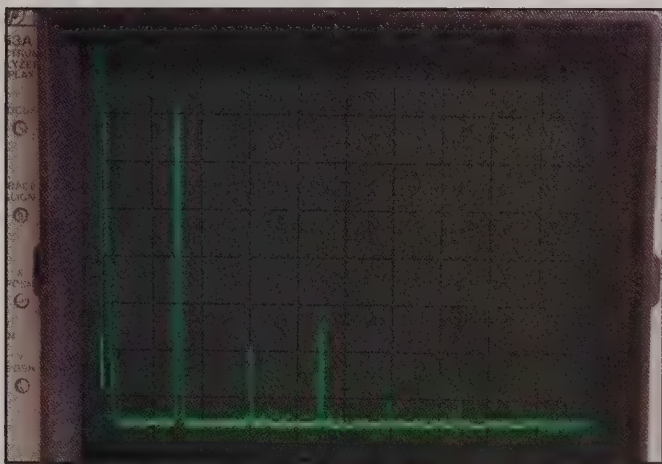

Photo 4. Spectral purity test (with no low-pass filter): 2f0 = –49 dBc; 3f0 = –44 dBc; 4f0 = –60 dBc; and 5f0 = –58 dBc.

Once the bias circuit is finished and tested, proceed to build the input circuit next. Once the input circuit is complete, then it is time to mount the FET. When mounting the FET to the heat spreader, I used high-performance thermal compound Arctic Silver 5. Be careful to use the correct amount, because too much or too little will not allow for proper cooling. There is plenty of information available online at the transistor manufacturers' websites. Remember the idea is to have the compound fill any voids between the transistor flange and the heat spreader only.

Now that the FET is mounted the output circuit can be completed.

Testing

I strongly suggest using a current-limited power supply for testing and limit it to only a few amps to start with. I also suggest that the drain voltage be reduced to between 40 and 45 VDC for initial testing. The combination of the current limiting and the lower drain voltage drastically increases the ruggedness of the RF FET. Under these circumstances you cannot expect much power but that is all right. You really want to ensure the amplifier has gain and appears to be working before seeing just what it will do. Do not go too low on the drain voltage, as it will change the matching and things will not appear to be correct.

Apply the drain voltage and adjust the bias to obtain 1 amp of quiescent (idle) current. Next apply a small amount of drive. From the results you see in the accompanying table, 100 mW of drive will make about 40 watts of RF output, if things are working properly. Use the table as a gauge for performance. Slowly work your way up in power and drain voltage. Proceed slowly because you do not want to use the FET as a fuse.

Also, be aware of your drive source. Make sure there are no chances of power output spikes in both level and spurious frequencies. I say this because I blew a high-power FET in a test,

driving it with a small wideband amplifier from Mini-Circuits®.

The amplifier was not the problem. My source was a HP 8640B signal generator. It is absolutely fine as long as the RF is off or on. When the RF is switched from off to on, it produces a spike in amplitude between 3 dB and 10 dB above where it is set and at a random spot in the frequency range of the generator!

I had the amplifier running at 700 watts out and switched the RF off. I turned the RF back on and the flash and sparks were amazing! This amplifier now tried to make between 1.4 kW and 7 kW somewhere between 1 and 500 MHz (who knows where?!). Therefore, make sure you know about your test setup behavior.

Performance

As shown in Table 1, this amplifier exhibits about 26 dB gain and can produce over 1 kW of RF output power. With the coaxial stub on the output the spectral purity by itself does not meet the –60 dBc mark required of commercial amplifiers. However, it is much better than what is typically seen from most 8877-type vacuum-tube amplifiers without a low-pass filter installed.

As for linearity, the 2-tone test at 1 kW PEP shows third-order IMD at –32 dB and fifth order IMD at –44 dB. On-the-air reports from local stations on SSB have been exceptional when running at 1 kW output.

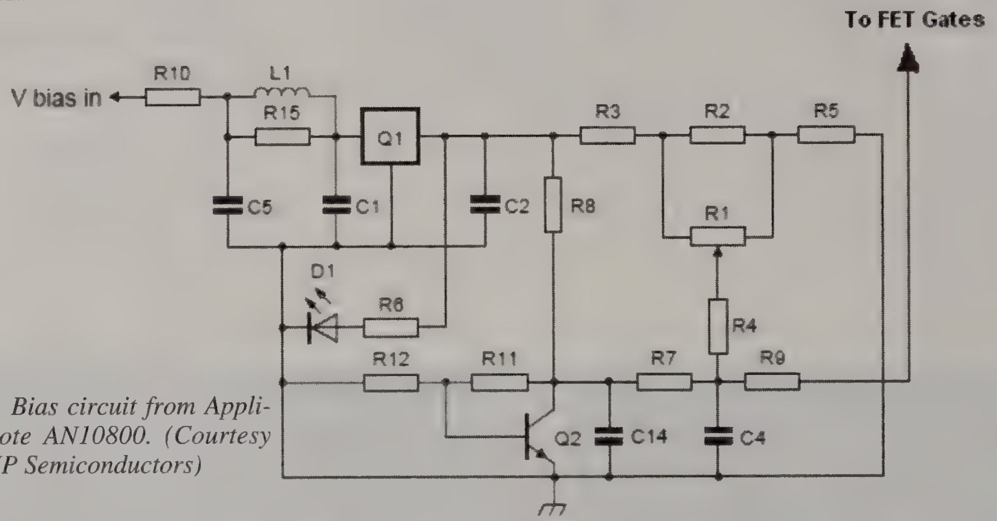

Figure 3. Bias circuit from Application Note AN10800. (Courtesy NXP Semiconductors)

RF P in	RF P out	Gain	Compression	Vdd	Id	Dissipation	Efficiency	IMD 3	IMD 5	IMD 7
0.0	0	0	0	48	1.0	48.0	0.0%			
0.1	41	26.13	0.00	48	4.4	170.2	19.4%			
0.2	82	26.13	0.00	48	6.5	230.0	26.3%			
0.3	145	26.84	-0.71	48	8.5	263.0	35.5%			
0.4	200	26.99	-0.86	48	10.1	284.8	41.3%			
0.5	265	27.24	-1.11	48	11.6	291.8	47.6%			
0.6	300	26.99	-0.86	48	12.6	304.8	49.6%			
0.7	340	26.86	-0.74	48	13.5	308.0	52.5%			
0.8	385	26.82	-0.70	48	14.5	311.0	55.3%			
0.9	430	26.79	-0.66	48	15.5	314.0	57.8%			
1.0	470	26.72	-0.59	48	16.4	317.2	59.7%			
1.1	500	26.58	-0.45	48	16.8	306.4	62.0%			
1.2	540	26.53	-0.40	48	17.6	304.8	63.9%			
1.3	570	26.42	-0.29	48	18.3	308.4	64.9%			
1.4	600	26.32	-0.19	48	18.8	302.4	66.5%	41	43	55
1.5	635	26.27	-0.14	48	19.4	296.2	68.2%			
1.6	660	26.15	-0.03	48	19.9	295.2	69.1%			
1.7	700	26.15	-0.02	48	20.5	284.0	71.1%			
1.8	725	26.05	0.08	48	21.0	283.0	71.9%			
1.9	760	26.02	0.11	48	21.6	276.8	73.3%			
2.0	800	26.02	0.11	48	22.3	270.4	74.7%	38	44	55
2.1	820	25.92	0.21	48	22.5	260.0	75.9%			
2.2	840	25.82	0.31	48	23.0	264.0	76.1%			
2.3	860	25.73	0.40	48	23.5	268.0	76.2%			
2.4	900	25.74	0.39	48	24.2	261.6	77.5%			
2.5	930	25.71	0.42	48	24.5	246.0	79.1%			
2.6	960	25.67	0.45	48	25.0	240.0	80.0%			
2.7	980	25.60	0.53	48	25.4	239.2	80.4%			
2.8	1000	25.53	0.60	48	25.9	240.8	80.6%	32	44	52
	1200							29	52	51

Table 1. Test results for the 1-kw amplifier using the NXP BLF578 push-pull transistor.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

ARISSat-1 On-Orbit Review, AO-51 (SK), Project Fox, AMSAT Space Symposium 2011 Report, and A Salute to 50 Years of Amateur Radio Satellites

As this is being ARISSat-1KEDR has gone silent. Also, let's salute an old friend, AO-51, now that it is a "Silent Key." Fox-1, the first of the Project Fox Satellites, assumes a new sense of urgency with the demise of AO-51. And finally, we have a report on the AMSAT Space Symposium 2011 and 50 Years of Amateur Radio Satellites.

ARISSat-1: On-Orbit Review

As ARISSat-1 approached its fifth month of service, it continued to perform very well. The pre-launch predictions of two to three months of service proved to be pessimistic. With its better than expected life, predictions began to turn optimistic, forecasting a re-entry in late January or sometime in February 2012.

After discovering that the broken 70-cm antenna was still long enough to be usable and that full operation in sunlight was still possible after the battery failure, operation settled down to a routine. The only major casualty was the Russian Kursk Experiment. To be successful, Kursk needed whole orbit data and this was no longer possible with the satellite shutting down when in eclipse.

Unfortunately, however, hopes for that optimistic extended life expectancy began to dim in mid-December. By December 21, 2011, from its initial altitude of about 380 km, the satellite's perigee had deteriorated to 270 km and was sinking fast. As the satellite encountered denser atmosphere, the rate of decay increased until the inevitable occurred. On January 4, 2011, AMSAT News Service issued the dreaded special bulletin: ARISSat-1/KEDR Goes Silent. Here are some of its contents:

> Reception reports indicate that ARISSat-1/KEDR stopped transmitting on Wednesday, January 4, 2012. The last full telemetry captured and reported to the ARISSatTLM web site at 06:02:14 UTC on January 4 were received from ground stations as the satellite passed over Japan…
>
> Telemetry reports showed that the temperature aboard ARISSat-1/KEDR had been rising as atmospheric drag began to affect the satellite…
>
> Konstantin, RN3ZF, sent a reception report of his copy of the 0842 UTC pass that indicated that "the telemetry was absent, voice messages were not legible, very silent and interrupted. Most likely, I saw last minutes in the life of the satellite." Dee, NB2F, reported, "Nothing heard from ARISSat-1/KEDR on any frequency during the first USA pass at 16:00 UTC, January 4."

ARISSat-1's life was now over.

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The satellite was deployed from the International Space Station on August 3, 2011 during EVA-29 by Cosmonaut/Flight Engineers Sergei Volkov, RU3DIS, and Alexander Samokutyaev. It lasted five months and part of one day. Here is more from that special bulletin:

> The satellite carried a student experiment from Kursk State University in Russia which measured atmospheric density. Students from around the world provided the voices for the FM voice announcements.
>
> The amateur radio payload aboard ARISSat-1/KEDR achieved many "firsts" for amateur radio in space:
>
> • First flight test of AMSAT Software Defined Transponder which transmitted simultaneous:
>
> • FM voice downlink cycling between student messages, spoken telemetry and SSTV from cameras on the spaceframe.
>
> • 16 kHz bandwith linear transponder,
>
> • CW beacon with telemetry and call signs of radio amateurs noting their significant contributions to amateur radio in space.
>
> • Robust, forward error corrected 1K rate BPSK downlink with satellite telemetry and Kursk experiment telemetry.
>
> • Development and release of the ARISSatTLM software for PC and Mac platforms enabled amateur stations worldwide with reliable reception of the BPSK telemetry, CW telemetry, display on the station's computer, and automatic upload of received data via the internet to the ARISSat engineering team.
>
> • A new Integrated Housekeeping Unit was developed and successfully flown.
>
> • A new Power Management System was developed and successfully flown.
>
> AMSAT President Barry Baines, WD4ASW, noted: "ARISSat-1/KEDR marked a new type of satellite which has captured the attention of the national space agencies around the world for the unique educational opportunity we have been able to design, launch, and operate. By designing an educational mission aligned with NASA's Science, Technology, Engineering, and Mathematics (STEM) goals, amateur radio operators around the world have been able enjoy a new satellite in orbit."
>
> ARISSat-1/KEDR Project Manager Gould Smith, WA4SXM, stated: "Dozens of amateur radio volunteers, AMSAT, ARRL, NASA, and Energia teamed up for this successful mission to bring you the most unique and innovative amateur radio satellite mission. Congratulations to all who made ARISSat-1 successful!"

Amateur radio operators and non-ham students and other listeners continued to use ARISSat-1 to the greatest extent possible while it was with us. After a rough start, ARISSat-1 turned out to be a "star performer."

The telemetry system continued to work very well. Thanks to over 70 telemetry contributors in over 41 countries, and Douglas Quagliana, KA2UPW/5's software and servers, it was

possible to easily look at near-real-time telemetry on one's iPhone, notebook, or home computer at any time.

Now that ARISSat-1 has reached the end of its life, amateur radio operators who received telemetry from ARISSat-1 at any time over the last few months are urged to forward all .CSV telemetry files to the telemetry website: <http://arissattlm.org>.

Salute to an Old Friend: AO-51 (SK)

After a long and very successful career, our old friend AO-51 has finally become a "Silent Key." A book has been written about all of its modes and features (available from the AMSAT Store). Some of the highlights I remember are: hearing the first telemetry, working the mode U/S and L/S transponders, many demos through it at hamfests and schools, retransmission of Sputnik's sounds on the 50th anniversary of Sputnik's historic flight, among many others. Drew Glasbrenner, KO4MA, sums it up better than I can:

November 29, 2011

It is with a heavy heart I report that AO-51 has ceased transmission and is not responding to commands. The last telemetry data indicated that the third of six batteries was approaching failure to short, and observations indicate the voltage from three cells is insufficient to power the UHF transmitters. The induction heating unit (IHU) may continue to be operative. Initial tests with the S-band transmitter were also not positive, although more attempts are in order. We have tried leaving the satellite in an expected state where if voltages climb high enough, the 435.150 transmitter may possibly be heard.

The command team will regularly attempt communications with the satellite over the coming months (and years). There is always the possibility that a cell will open and we could once again talk to our friend while illuminated. Thanks to all who helped fund, design, build, launch, command, and operate AO-51. Its seven year mission has been extraordinary. Please support AMSAT's Fox-1 project, and other AMSAT projects worldwide with your time and money.

For the AO-51 Command Team . . .

73, Drew Glasbrenner, KO4MA
AMSAT-NA VP Operations

Project Fox: More Important than Ever

Now that ARISSat-1's mission has ended, AMSAT has returned to work on Project Fox. This effort was approved by the BoD a couple of years ago but had been overtaken by the ARISSat-1 effort. With the recent failure of batteries on AO-51, this project takes on more urgency. It has now been split into a two phase program—FOX-1 and FOX-2. FOX-1 will be a replacement for the FM transponder on AO-51 done quickly due to the current urgency. FOX-2 will include a software defined linear transponder and other features. Development of FOX-2 will lag FOX-1 due to limited assets. Further details are available at: <http://www.amsat.org/ amsatnew/fox/>. A complete report of all aspects of Project Fox was presented at the 2011 AMSAT Symposium.

On November 15, AMSAT submitted a proposal to NASA for its CubeSat launch initiative, also known as the "Educational Launch of NanoSat" (ELaNa) program. NASA selects projects that it deems to have merit in support of its strategic and educational goals. Projects that are selected will be able to enter into a collaboration agreement where NASA will cover the integration and launch costs of the satellite. Hopefully FOX-1 will be one of the winners to be announced by 30 January 2012. Success would provide major help in funding the FOX-1 development and launch.

Photo 1. Technical Achievement Award Presentation. Left to right: Barry Baines, WD4ASW, President AMSAT; Phil Karn, KA9Q, recipient of ARISSat-1 Telemetry Algorithm and Software Development; Tom Clark, K3IO, AMSAT President Emeritus; and Howard Long, G6LVB, developer of the FunCube Dongle and the LVB Tracker.

AMSAT Space Symposium'11 and Salute to 50 Years of Amateur Radio Satellites

The 2011 AMSAT Space Symposium and General Meeting in San Jose, California, on November 4–6, 2011 is now history. The AMSAT Board of Directors shared the same venue on 3–4 November. Plans were made for the future of AMSAT for this year, 2012. The format of these meetings was the same as ever, featuring the following items:

• AMSAT Board of Directors Meeting: Heavy emphasis on Education this year. As recent follow-up to conversations during the BoD Meeting, Doug Loughmiller, W5BL, has been appointed Editor of the *AMSAT Journal*, and Mark Hammond, N8MH, has taken on the task of coordinating AMSAT's Educational Efforts. Welcome Doug and Mark!

• Technical and Operational Presentations: Featured ARISSat-1, Project Fox, and other new "Birds." Jan King, VK4GEY/W3GEY, highlighted these presentations with a history of satellites during his time at AMSAT, ranging from OSCAR-5 through the Microsats and the early high-altitude satellites.

• AMSAT Annual Meeting: President's "State of the Union" presentation to the members. Award presentations, including the new AMSAT Technical Achievement Awards presented to Phil Karn, KA9Q, and Howard Long, G6LVB (see photo 1).

• Banquet with Featured Speaker: Lance Ginner, K6GSJ, presenting the history of OSCAR-1 and the early days of Project OSCAR. Fifty years of Amateur Radio Satellites. (See photos 2 and 3.)

Photo 2. Lance Ginner, K6GSJ, OSCAR-1 Fiftieth Anniversary Presenter, and Mrs. Ginner.

• Area Coordinator's Breakfast: How to get the AMSAT word out at hamfests, meetings, etc.
• Tours: The San Jose Tech Museum of Innovation, and the Big Dish at Stanford University.
• Many ragchews and discussions.

This year the attendance was a little light, but the quality of all of the presentations made up for it. I always enjoy the technical presentations, but it was really a breath of fresh air to hear David Palmer, KB5WIA, talk about a backpacking satellite grid square expedition to a very rare grid, CM79, on the California Pacific Coast.

Photo 3. Lance Ginner, K6GSJ, and Bob Allison, WB1GCM, of ARRL lab with OSCAR-1 prototype.

Next year the AMSAT Space Symposium will be in Orlando, Florida. Start making plans now to attend.

Summary

Let's wish ARISSat-1 a hearty farewell. It represented a golden opportunity to showcase amateur radio and amateur radio satellites to kids in the classroom, and to promote STEM instruction while having "hands-on" and "heads-on" fun. Unfortunately, it did not reach as many kids as planned due to timing, late publicity, etc. Let's start planning soon for the next one.

Continue the Amateur Radio Satellites in Education theme with Project Fox. It is a natural carry-on to ARISSat-1, and will be AMSAT-NA's next satellite. Fox-1 will fill the void left by AO-51's demise. Support FUNCube, a similar AMSAT-UK satellite that may launch before Project Fox, and don't forget KIWIsat from "down under."

Please continue to support AMSAT's plans for the future of amateur radio satellites. AMSAT is now updating its web page at <http://www.amsat.org> on a much more regular basis. Satellite details are updated regularly at <http://www.amsat.org/amsat-new/satellites/status.php>. Follow the projects and progress of AMSAT-UK at <http://www.uk.amsat.org/>. Until next time!

73 de Keith, W5IU

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Automated Bearing-taking, Mapping, and Sharing

I like to watch old movies and get glimpses of the technologies of the times when they were made. I especially like seeing the portrayals of radio direction finding (RDF).

In the 1949 classic gangster film-noir *White Heat*, James Cagney portrays Cody Jarrett, a psychopath who breaks out of prison and rejoins his mob to lead an attempted payroll heist at a chemical plant. Undercover agent Hank Fallon, played by Edmund O'Brien, infiltrates the gang but needs a way to let the cops know exactly where the heist will be. Jarrett didn't trust his own gang members enough to tell them in advance, so Fallon rewired a table radio into a transmitter and put it on the tanker truck that was going to be a Trojan Horse entering the plant with gangsters hiding inside.

As the climax approached, the good guys were in cars and vans with rotating loop antennas on top. With emotionless voices, they radioed their bearings back to headquarters, where two men plotted them on a giant wall map of Los Angeles, California. The map was so big that one officer had to stand on a ladder to draw lines on it with a large protractor and ruler. Of course, the bearings all crossed precisely at the plant entrance as the tanker went in. The rest was just good, old-fashioned intrigue and gunplay.

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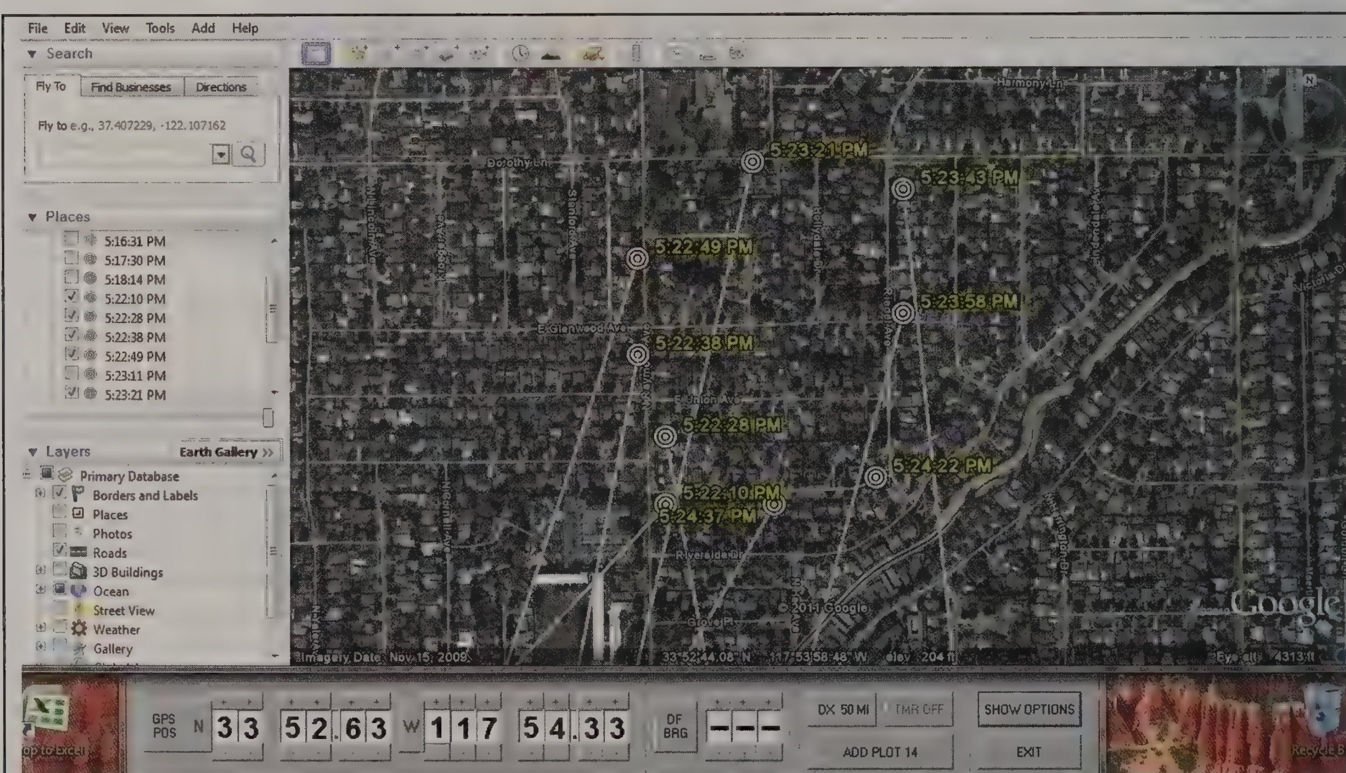
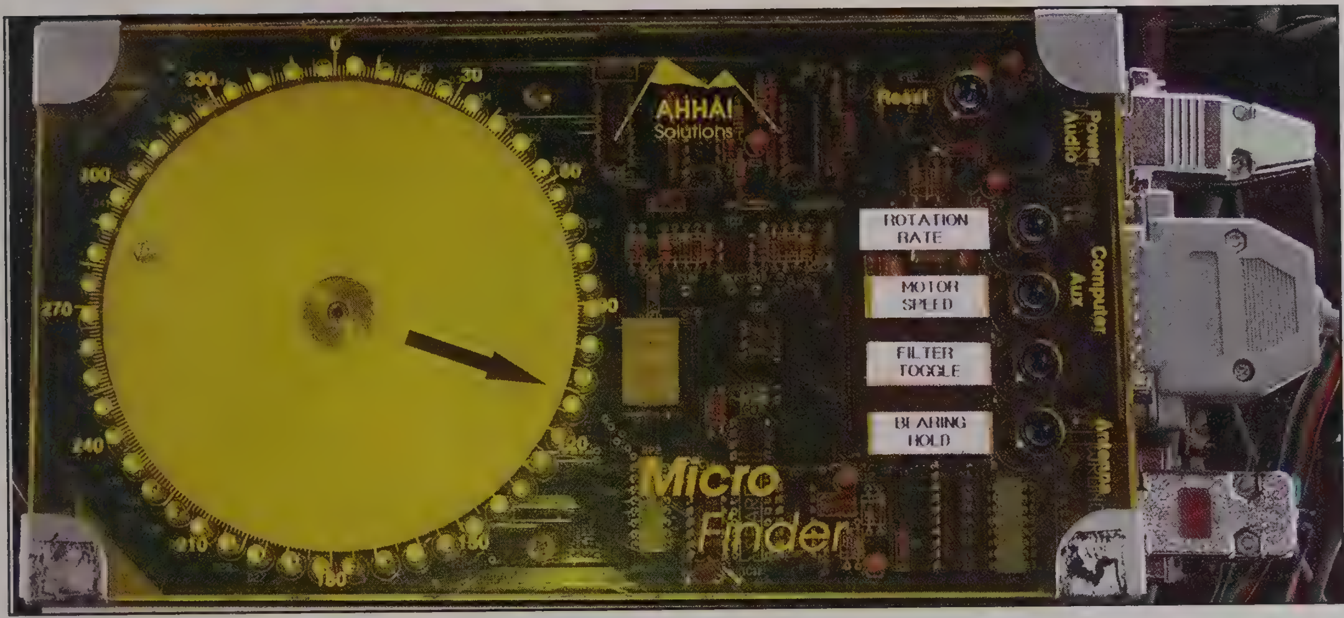
That was the best technology of the day. Three decades later, moviemakers preferred to show technology that didn't really exist. Spy-movie heroes would put tiny transmitters on a bad guy's car to tail him. A screen below the dash of the pursuit car showed the villain's exact location as a bright dot on a moving map.

Real police detectives were using covert RDF tracking at that time, but the dot-on-the-map display was only a dream to them. In 1986, the LoJack™ Corporation began equipping police cruisers and aircraft in Massachusetts with Doppler RDF sets so that officers could track down transmitter-equipped stolen cars before they were chopped or driven out of town.[1] There was no map display for the officers, just a circle of lights indicating the stolen car's direction relative to the cruiser or aircraft.

With just the LED ring plus the bearings reported by follow officers and some fixed stations, with regularity the authorities started catching car thieves red-handed. The system became very successful and continues to be so today. LoJack claims responsibility for over 300,000 recoveries of stolen vehicles and construction equipment.[2]



Connected to a MicroFinder Doppler set, GoogleHunt plotted this series of bearings to a distant repeater along streets in my neighborhood.



The MicroFinder by AHHA! Solutions has a 50-LED circular display and a large bearing pointer driven by a stepper motor. Its Agrelo-format output works with APRS and GoogleHunt. MicroFinder kits are no longer marketed, but used units can be found at attractive prices. (Photo by Joe Moell, KØOV)

Ham radio's RDF enthusiasts have closely followed each new advance in vehicle navigation. Here in southern California, most mobile transmitter hunts are scored by mileage, not time. Instead of paying attention to the clock, we watch our odometers. In the 1970s, we all visited the Auto Club regularly to get the latest street maps. The Navigator[3] on each vehicular hunt team plotted the bearings and attempted to determine exactly where the hidden transmitter might be. Then he or she tried to discern the minimum-mileage route to it.

When in-car computing first became practical in the 1980s, we tried out every new development for bearing plotting. Starting with BASIC programs on Sinclair Z-80s, we moved on to Excel spreadsheets on PCs. Both of those performed the trigonometry well enough to predict the radio fox's location, but we still had to plot by hand the numerical results on our paper maps.

APRS and Foxhunt

A big breakthrough in the early 1990s was Automatic Packet Reporting System (APRS), a MS-DOS program for the exchange of location information. The map screens of APRS display the position and movement of all stations that periodically transmit their latitude and longitude. With APRS, our GPS coordinates were automatically plotted for us and we always knew where we were, limited only by map accuracy and detail.

When Bob Bruninga, WB4APR, created APRS-DOS in QuickBasic, he included RDF features to plot bearing azimuths that were entered by hand or via RS-232 serial port from Doppler RDF models of the day. With a simplex APRS packet network, all hunt participants could see each other's bearings on their own computers and triangulate them. Of course, that connectivity wasn't what we wanted for competitive hunting, but it was ideal for cooperative searches for interference or stations in distress.

At the time, digitized map suppliers were insisting on royalties for every copy of every map. Therefore, WB4APR developed his own mapping system. Anyone with patience could create maps for APRS, and many did. Mobile computers of the time didn't have the gigabytes of storage and gigahertz of processing speed that we take for granted now, so APRS-DOS maps were small files that usually were limited to major highways and freeways.

Details of the Agrelo Bearing Format

The Agrelo serial bearing format got its name from the Agrelo Engineering DFjr, which was the first Doppler set to use it. The format is "%BBB.B/Q<cr>" where

% is message start character
BBB.B is signal bearing degrees (000.0 to 359.9)
Q is bearing signal quality (1 to 8)
<cr> is Carriage Return

There are significant variations among Doppler sets in their implementation of this format. The AHHA! MicroFinder uses BBB.B to give bearings in tenths of a degree precision, but others use only whole degrees (BBB). The APRS standard calls for an estimated bearing quality of 1 to 8, where 8 is best. PicoDopp does not compute quality and always outputs Q = 7. Other Dopplers generate values of quality using various methods. For instance, the Agrelo DFjr computes the standard deviation (SD) of the headings from a continuous set of 128 antenna rotations. Best bearings have smallest SDs. The MicroFinder determines quality based on measurement of the second harmonic content in the induced Doppler tone. Bearings are best when second harmonic is least.

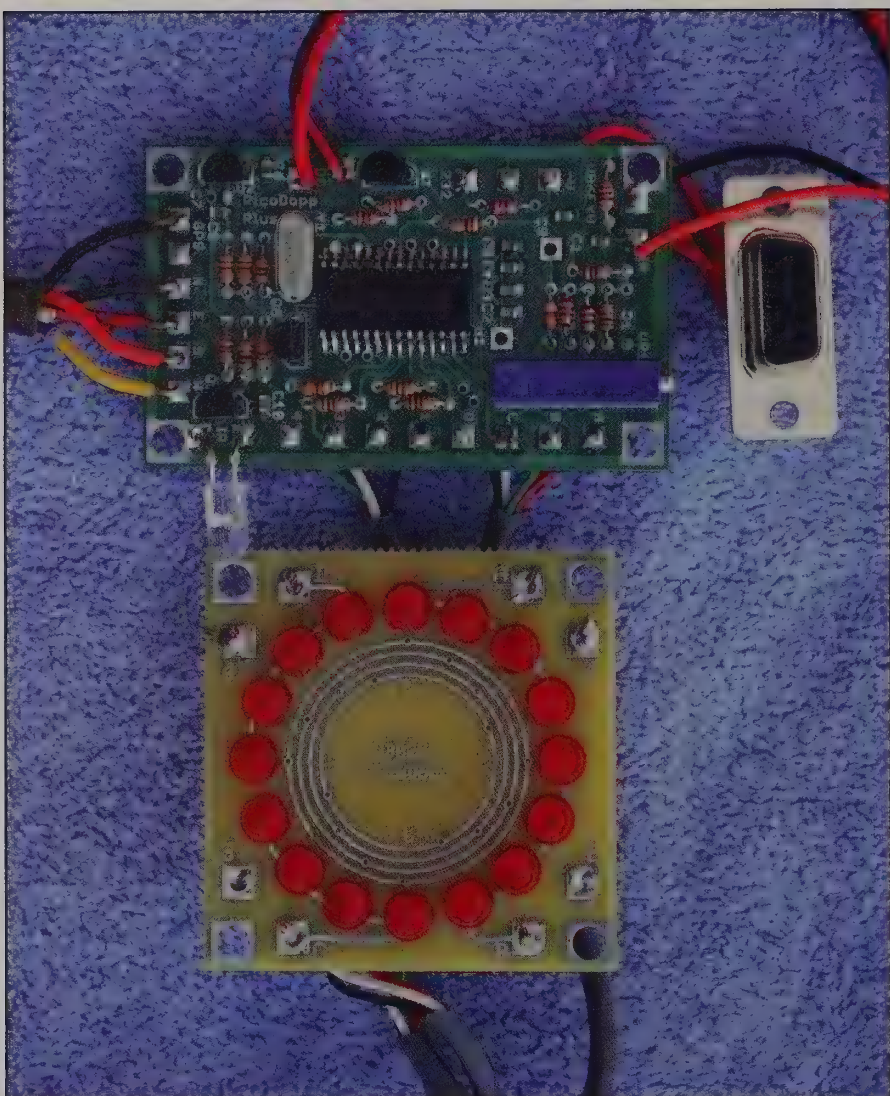
All of the Dopplers mentioned in this article put out the serial bearing stream in RS-232 ASCII at 4800 baud. The GPS used with these Dopplers must also have RS-232 output at that rate. GPS sets with USB output are not compatible.

What we really yearned for was mapping to the residential street level. As commercial (e.g., Delorme) and governmental agency (e.g., TIGER) map files became available on CD-ROMs, we tried them all. Several hams created versions of APRS that utilized these mapping products, but most of these versions did not have the automatic RDF-bearing plotting features of APRS-DOS.

Soon after Google Earth became free to all in 2005, transmitter hunters began working on ways to utilize its extraordinary mapping, positioning, and navigating powers. One of the first to make a product available was Bob Iannucci, W6EI, of Palo Alto, California. His free FoxHunt app[4] for iPhone 3GS uses the internal GPS and compass along with Google Earth to plot and triangulate bearings on a single hand-held device.

FoxHunt works with any RDF system, but there's no direct connection to RDF gear. After getting a bearing, the user looks in that direction while holding the iPhone directly in front. The phone's GPS engine and internal compass determine location and azimuth, and then the program puts a bearing ray on the display map. When multiple bearings are entered, the program triangulates and displays possible transmitter locations.

The FoxHunt app is a boon for on-foot RDF. It works so well that it's not allowed in the woods at international radio-orienteering competitions. W6EI is now working on a matching Doppler RDF set and a networked version of FoxHunt for bearing sharing. Neither is available to the public as of this writing in December 2011.



The PicoDopp processor board with the optional 16-LED display board beneath it. Display boards with more LEDs and numerical readout are available. Note the infrared LED on the bottom of the processor board for transmitting bearings to PalmOS devices. (Photo by KØOV)

GoogleHunt

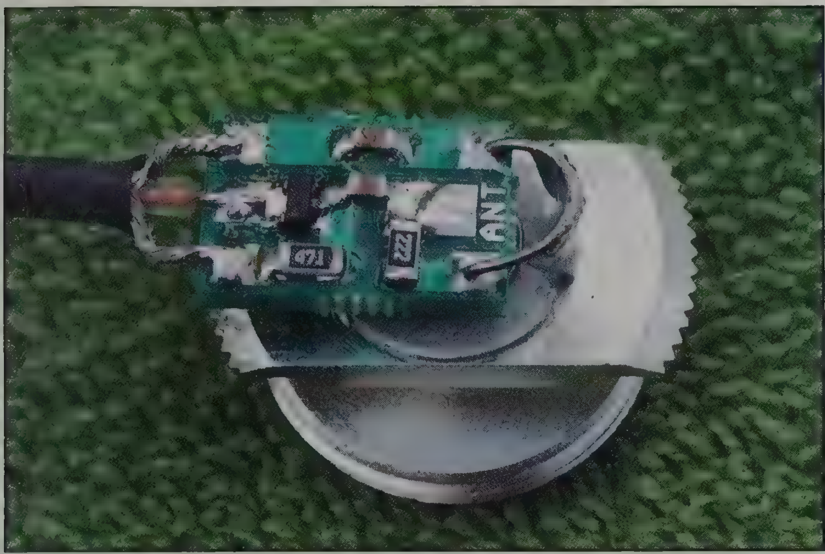
When I tested PocketAPRS for PalmOS a few years ago, I concluded that the screens on hand-held devices are too small for a driver to use successfully on mobile hunts. Better for that is a laptop PC screen and the free GoogleHunt program[5] by Bob Simmons, WB6EYV, of Santa Barbara, California. It runs on Windows® in tandem with Google Earth and provides a very simple interface between that program, a GPS unit, a Doppler RDF set, and the user. GoogleHunt does this by generating KML files that GoogleEarth parses and displays. The GPS and the Doppler make it automatic and hands-off, but bearings and locations can also be entered from the keyboard.

I tested GoogleHunt with a Magellan Gold GPS unit and a MicroFinder Doppler set. GPS-friendly Dopplers such as MicroFinder receive coordinates, direction of travel, and velocity in NMEA-0183 format from the GPS at 4800 baud. They then send this data on to the PC, interspersed with RDF bearings in Agrelo format (see sidebar).

I made the GoogleHunt plot in the accompanying illustration as I drove the streets in my neighborhood and the MicroFinder took bearings on an active repeater output frequency. On the map each bearing has a "target" at the location where it was taken, a time stamp, and a line indicating the true bearing.[6] Below the overhead view is the GoogleHunt console showing current latitude, longitude, and bearing in degrees. When serial data isn't streaming in, the up/down arrows on each digit can be used to manually update these values.

GoogleHunt can display up to a hundred locations and bearing lines at a time. The ADD PLOT button keeps track of the number of bearings. The DX button selects the length in miles of the bearing lines. Unwanted bearings can be suppressed by going to the CURRENT HUNT file under PLACES in the Google Earth console.

In the TIMER mode, GoogleHunt can be configured to automatically generate bearing plots at intervals of one, two, five, or ten minutes when location and bearing data is available. That might be convenient when you're driving alone and tracking a steady signal. However, there



A PicoDopp termination board with PIN diode, mounted to a NMO antenna base. This assembly will pass through the standard 3/4-inch mounting hole for these mounts. The board can be used with other whip and dipole configurations. (Photo by KØOV)

are many situations where this could cause confusion, such as a foxhunt with multiple transmitters on the same frequency or a repeater input with numerous users. I prefer manually commanding each bearing plot by hitting the space bar on the computer. To avoid screen clutter and to get the best bearings for triangulation, I try to plot them only from high locations when the signal I'm tracking is coming in clearly with a minimum of multipath flutter.

Google Earth fetches satellite images from the internet and stores them in your computer's cache memory for fast retrieval. This means that a live internet connection in the vehicle is not needed for GoogleHunt, provided that Google Earth on that PC has previously "visited" the area where you are doing RDF. In the lower right corner of the map is the eye level, which is 4313 feet in this case. To view street names, the eye level must be less than about 5000 feet. Viewing of cars, driveways, and similar details requires an eye level of 1000 feet or less.

Before setting out on a transmitter hunt or RDF mission, run Google Earth with a fast internet connection at the lowest eye level you will need. (GoogleHunt does not need to be running with Google Earth for this.) Scan over the entire area of the hunt slowly enough that all the images load. This will put them into your computer cache at the maximum resolution you will need for hunting.

Bob has put a lot of work into making GoogleHunt easy to use. The hardest part for me was installing a RS-232–to–USB adapter on the Windows 7 PC and finding the right COM port. Then it was merely a matter of configuring my Doppler for an optimum rate of position and bearing updates. There was some trial-and-error to this task, because GoogleHunt won't plot bearings when the vehicle is stopped or moving at less than 3 knots. Usually that's good, because GPS units don't report accurate headings at very low velocities, but an override of that feature for testing would be nice.

PicoDopp

Over the years, several commercial products have incorporated the Agrelo serial bearing interface including the DFjr by Joe Agrelo, N2OOC (Agrelo Engineering), the DSP-RDF by Dan Welch, W6DFW (sold through Byonics), and the MicroFinder by Rich Harrington, KN6FW (AHHA! Solutions). None of them is currently in production, but if you find a working used unit, it should be compatible with GoogleHunt. They all combine the GPS and RDF data into a single serial input to the PC, although there are differences in the number of positions and bearings sent out per minute.

The only Doppler products with Agrelo-format output now being marketed are designs of WB6EYV. Bob sells PicoDopp through his company, Doppler DF Instruments. It appears "stripped down" at first glance, but it is actually a sophisticated digital-signal-processing system implemented in firmware for the Microchip 16C773 PIC on a 1.5 × 2.5 inch board. It produces antenna-switching signals at 430 pseudo-revolutions per second and then processes the Doppler tone that is induced into the user's receiver with a very narrow bandwidth switched-capacitor filter.

Doppler RDF units for hams traditionally have employed zero-crossing detectors to detect phase of the Doppler tone relative to the antenna switching, which determines apparent direction of the incoming signal.[7] WB6EYV prefers a novel "resolver" approach. Voltages from the Doppler tone that accumulate on the four switched filter capacitors are proportional to the sine and cosine values of signal direction. The PIC makes relative measurements of these voltages, mathematically divides them to get the tangent of the bearing, and then performs an arctangent routine to determine the numerical bearing in degrees.

PicoDopp is not plug-and-play. It comes to you as a set of assembled and tested circuit boards that you will need to wire together and mount in the enclosure of your choice. If you have built electronic kits and can handle the pack-

The DoppSite demonstration station near Washington, DC as viewed on Google Earth. It is not connected to a RDF set, but it simulates how the bearing periodically updates.

aging details, Bob's extensive documentation should get you the rest of the way. These docs are available on his PicoDopp website.[8]

A complete standalone PicoDopp consists of the main processor board, antenna board, and a display board. The processor board is intended to connect to a +13.8V vehicular source but will operate from +9 to +16 volts. It has a 78L05 regulator to provide +5 volts to the PIC and all interface circuits.

PicoDopp's wideband hard-switched antenna electronics are based on my design[9] to minimize parasitic effects in the array. The supplied antenna board (100 to 1000 MHz) breaks into five parts, a 1.85-inch-square switcher section and four 0.40 × 0.55 inch PIN diode termination sections for mounting at the feedpoints of four identical antennas, which can be mobile whips or vertical dipoles. The termination boards are small enough to mount directly to the bases of NMO-type whip mounts, as shown in the photo.

The processor board has three forms of bearing output: parallel 8-wire (two updates per second), serial RS232 (ten updates per second), and serial infrared (five updates per second). Buyers can choose from three optional display boards for standalone use: 16-LED circle, 3-digit numeric, and 36-LED circle plus numeric. Cost of the PicoDopp board set plus the least expensive display board is about two-hundred dollars plus shipping.

DoppSite

Regularly, I receive requests for information about linking together RDF systems at several stationary sites for automatic triangulation. The newest software product from WB6EYV can do that via the internet. Bob's DoppSite program enables remote viewing of RDF stations on Google Earth maps. The program can drive multiple displays and each display can plot multiple sites, making an area-wide RDF network possible.

With DoppSite, a Windows PC, an Agrelo-format RDF set, and a fast internet connection, you can generate a website that sends bearing plots on Google Earth maps and updates them as often as once per second. Bearings taken at your site can be continuously viewed by other Google Earth users with internet connections. Whether your site is public or private is merely a matter of how you distribute the access information for it.

DoppSite is intended to operate only at fixed RDF stations. You will need to provide the static IP address and port number of your DoppSite computer for others to access it. Your service provider may be able to provide an unchanging IP address or you can utilize a DNS management service such as No-IP[10], as Bob explains in his extensive documentation.

DoppSite web stations can be viewed from any internet-connected computer running Google Earth. Bob has arranged for a demonstration DoppSite[11] near Washington, DC that you can access to see how remote plots would appear on your computer. You can also download a free trial version[12] of the DoppSite program to try out with your own computer and RDF set. With it, you can set up a test RDF website and solve any problems

with IP addresses and ports. However, the trial version's RDF bearing lines are only one mile long.

The full version of DoppSite is available directly from WB6EYV. List price is $99, but it is free with the purchase of a PicoDopp board set. Maximum bearing line length in the full version is 20 miles, which is adequate for most VHF/UHF RDF applications. Longer bearing lines would be prone to error due to curvature of the Earth.

Bob Simmons is an amazingly prolific hardware designer and software writer. In addition to the products I have described above, he has made several bearing display programs available at no charge. They include WinDopp PC, which receives the Agrelo-format stream and paints a series of headings in polar format on Windows PCs. There are versions of this program for old MS-DOS computers with RS-232 ports (PicoDopp PC) and for PalmOS devices with infrared interface (FoxPlot PDA). They can be used in place of an LED display board in a PicoDopp system.

WB6EYV moderates the PicoDopp forum on YahooGroups[13] where you can learn more and ask questions about any of his products. The lively theoretical and practical discussions there often lead to new products and improvements to current ones. You do not have to be a purchaser to join this forum and you can read the message archives without joining.

This discussion of Doppler sets and bearing mapping wouldn't be complete without a few words about accuracy. A well-constructed and installed[14] mobile VHF/UHF Doppler set will give excellent bearings most of the time, especially when the target signal is only a few blocks away. But just because. your Doppler's serial output is in decimal degrees or even tenths of a degree, don't fool yourself into thinking that your bearings with it are that accurate, especially when the target isn't line-of-sight. Hills, buildings, and other large objects in the path can easily cause significant bearing errors. Bearings to targets across bodies of water are subject to error due to refraction effects.

A good rule of thumb is to assume that Doppler bearings taken under "good" conditions are accurate to ±5 degrees. A 5-degree error at 11.5 miles distance causes a line-of-bearing to miss the target by one mile. For a near-worst-case example, my GoogleHunt illustration was made with bearings on the output of a 2-meter repeater that was 45 miles away over a combination land and ocean path. The inconsistencies in the plotted bearings are easy to see. The bearing intersection points are not triangulated fixes. For an actual hunt under these conditions, I would have sought out a nearby hill and taken a reference bearing with a beam antenna.

Whenever you experiment with mobile computer mapping and tracking, keep safety in mind at all times. Have solid mounts for your computer, GPS, and RDF gear so they can't fly about. Minimize distractions and pay full attention to the road while driving. Get a helper to handle the computer and RDF gear when you drive, or get someone else to drive so you can concentrate on the RDF task. Carefully check your cable wiring to prevent expensive damage to RS-232 hardware. Take your time and have fun!

73 de Joe, KØOV

Notes

1. Details of the LoJack™ system are in "Homing In" for May 1991, *73 Magazine*.
2. <http://www.autotheftblog.com>
3. Sometimes jokingly called the "Navi-guesser"
4. <http://foxhunt.rail.com>
5. <http://www.silcom.com/~pelican2/PicoDopp/PICODOPP.htm#GH>
6. "True" in this case doesn't refer to accuracy. It means that the bearing is relative to true (not magnetic) north.
7. Details of Doppler RDF processing are in "Homing In" for March 2003, *73 Magazine*.
8. <http://www.picodopp.com>
9. <http://www.homingin.com/newdopant. html>
10. <http://www.no-ip.com>
11. <http://www.silcom.com/~pelican2/PicoDopp/DD_LIVE.html>
12. <http://www.silcom.com/~pelican2/PicoDopp/PICODOPP.htm#DS>
13. <http://groups.yahoo.com/group/PicoDopp>
14. Tips for optimum-performance vehicular Doppler antenna installations are in "Homing In" for July 2003, *73 Magazine*.

By Bob Witte,* KØNR

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

10 Meter FM: The Other VHF Band

The classic definition of the VHF spectrum is 30 to 300 MHz. Often in ham radio circles we may just say that VHF starts at 50 MHz and goes up from there, since the 6-meter band is our lowest amateur radio allocation. However, this completely overlooks what is happening at 29 MHz in the 10-meter band.

Almost VHF

Technically, the 10-meter band is considered HF, but it is so close to VHF that we'll go ahead and call it "The Other VHF Band." After all, 29 MHz equals 30 MHz, for large values of 29 MHz. Ten Meters is the only HF band with FM and repeater activity, which gives it something else in common with the VHF bands.

Now why would we want to run FM on 10 meters? (See table.) For the same reasons that we run FM everywhere else: clarity of signal, ease of tuning, suppression of static, and effective squelch operation. Instead of listening to all of the static, noise, and "Donald Duckness" of SSB, the FM transceiver sits there quietly until a strong signal punches through from a band opening. FM operating is easy on the ears and a lot of fun.

As propagation on 10 meters has improved over the past year, 10-meter FM is coming back to life. Ten-meter FM benefits from two major long-distance propagation modes: sporadic-*E* and *F2*-layer skywave propagation. Sporadic-*E* propagation tends to appear every year, and is the same phenomenon that fuels the 6-meter band during the summer months. *F2* propagation depends on solar activity, which clearly is on the upswing. It is great to have the sunspots back!

FCC Regulations

One of the disadvantages of FM is that it generates a wider bandwidth signal than SSB. This is why it is used only on a portion of the 10-meter band and the higher VHF/UHF spectrum.

10 Meter FM Frequencies

FM Simplex: 29.6 MHz

Repeater Frequencies

Input	Output
29.520 MHz	29.620 MHz
29.540	29.640
29.560	29.660
29.580	29.680

The way the FCC Rules restrict FM on the HF bands is actually quite subtle. In Part 97.305 of the FCC Rules, the following note is attached to the phone bands below 29.0 MHz:

(1) No angle-modulated emission may have a modulation index greater than 1 at the highest modulation frequency.

Both frequency modulation and phase modulation are considered "angle modulation," since both modulate the phase angle of the carrier. The de facto standard for amateur radio FM is 5 kHz peak deviation, which has a modulation index of 1.67 (assuming 3 kHz modulation frequency). Because the modulation index exceeds 1, this emission type is legal in the U.S. only above 29.0 MHz.

Note that FM is legal on the other HF bands, if the modulation index is kept below 1, but this is not commonly practiced (nor would I recommend it). See the sidebar "FM Bandwidth and Modulation Index" for more information.

The FCC also places a limit on 10-meter repeater operation, restricting it to the frequency range of 29.5 to 29.7 MHz. While we can operate 5-kHz deviation FM simplex down to 29.0 MHz, the repeaters must stay above 29.5 MHz. Note that in the U.S. a General Class license or higher is required to use these frequencies, which means that Tech-

FM Bandwidth and Modulation Index

There is quite a bit of confusion about FM deviation, modulation index, and bandwidth. A thorough analysis of angle modulation signals (frequency modulation and phase modulation) is mathematically intense, but Carson's Rule provides a simple way to estimate the bandwidth of an FM signal.

Carson's Rule originated in a paper written by J. R. Carson in 1922, which says the bandwidth ((BW) of an FM signal is given by:

$$BW = 2(\Delta f + f_m)$$

where Δf is the peak frequency deviation and f_m is the highest modulating frequency.

For voice communications, the modulating signal is normally band limited to 3 kHz, so that is the highest modulating frequency. For the common 5-kHz peak frequency deviation, Carson's Rule calculates a bandwidth of BW = 2 (5 + 3) = 16 kHz.

The modulation index, h, is given by:

$$h = \frac{\Delta f}{f_m}$$

Part 97.305 of the FCC Rules requires that FM signals below 29.0 MHz have a modulation index of less than 1. FM signals with peak frequency deviation of 5 kHz do not meet this requirement, since h = 5/3 = 1.67.

Some amateur and commercial transceivers provide for an FM deviation setting of 2.5 kHz, which results in a modulation index, h = 2.5/3 = 0.83. This does meet the FCC requirement for frequencies below 29.0 MHz. However, it produces a signal that is much wider than the more common SSB signal. Carson's Rule estimates the bandwidth as BW = 2 (2.5 + 3) = 11 kHz.

Some radio amateurs have incorrectly concluded that 2.5-kHz deviation FM signals are comparable bandwidth to conventional amplitude modulated (AM) signals. This is not correct, since AM bandwidth is twice the highest modulating frequency, BW = 2 × 3 kHz = 6 kHz. Single-sideband (SSB) signals are roughly 3 kHz in bandwidth, or half the bandwidth of AM. So we see that even the narrower 2.5 kHz deviation FM signals consume almost twice the spectrum as the very inefficient AM signals. When these FM signals are compared to SSB, they are almost four times wider in bandwidth.

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nician Class licensees do not have access to 29 MHz FM.

Following the FCC Rules is important, but we also need to pay attention to the "gentleman's agreements" of the band plans. The ARRL Considerate Operator's Frequency Guide <http://www.arrl.org/files/file/conop.pdf> shows this usage of the upper end of the 10-meter band:

29.000–29.200	AM
29.300–29.510	Satellite downlinks
29.520–29.580	Repeater inputs
29.600	FM simplex
29.620–29.680	Repeater outputs

The 10-meter satellite subband extends from 29.3 to 29.510 MHz. This satellite subband does appear to be declining in use, based on my review of the AMSAT website. However, there are satellites listed as "semi-operational" that have downlinks on 10 meters, so non-satellite operators should continue to avoid this frequency range.

10-meter FM Equipment

If you have a modern HF transceiver, it may very well be capable of FM operation (figure 1). Currently, almost all HF transceivers include FM as a standard modulation type, ready to go on 10 meters. There are a number of other, less-expensive options for getting on 10 FM. Alinco offers the DR-03T transceiver, a 10-watt single-band FM radio for 10 meters (figure 2). The Yaesu FT-8900 is a classic mobile FM transceiver that covers four bands: 10 meters, 6 meters, 2 meters, and 70 cm.

Surplus FM transceivers from the adjacent land-mobile radio can be tuned up for the 29-MHz ham band. This commercial band is usually referred to as *VHF Low Band*, covering the frequency range of 30 to 50 MHz. Reliable, used equipment made by Motorola, GE, Kenwood, Midland, etc., can be deployed on the ham band at very reasonable cost.

Years ago a popular technique was to retune CB radios and modify them for FM operation on 10 meters. Recall that standard CB uses AM, so the modulation circuits need to be changed to do FM. (Some hams also used them for 10-meter AM.) Recently, this trend has reversed itself. There are a number of 10-meter amateur transceivers on the market that are obviously targeting CB users. These 10-meter radios typically include AM, SSB, and FM and easily can be modified to operate on the CB channels with higher power than a legal CB radio. At first look, these radios seem like reasonable 10-meter transceivers, but they seem to be targeted at a different market, so buy with caution.

You'll need an antenna that works for 29 MHz. If you already have a 10-meter antenna, you can probably use it for 10-meter FM, but check the SWR at the higher operating frequency. The FM portion of the band is considerably higher in frequency than the CW or SSB segments, so you may experience a higher SWR at 29 MHz.

For mobile operating, there are many antenna choices. One option is to use a land-mobile antenna such as a Larsen NMO-mount low-band VHF antenna. The common Ham Stick® type antennas are available for 10 meters, and many CB antennas can be shortened to work on 10 meters.

Getting On the Air

After you get your radio gear figured out, the next step is to get on the air. If you do have a 10-meter repeater in your area, you should get in touch with those users. You'll likely find a bunch of 10-meter FM enthusiasts hanging out there.

The *2011–2012 ARRL Repeater Directory* lists about 100 or so repeaters on 10 meters in the USA. This is not very many repeaters compared to 2 meters, and some states list no 10-meter repeaters at all. Most of these repeaters employ tone access (CTCSS) to keep distant signals from inadvertently activating the repeater during band openings. The standard repeater offset is –100 kHz, with the repeater input below the repeater output.

Repeater or not, you can start monitoring 29.6 MHz simplex during the daylight hours. You probably will hear signals popping in from all over North America, and maybe around the world, depending on band conditions. It is common to hear signals from other continents when 10 meters is wide open.

You'll notice that the ARRL guide only lists one simplex frequency, 29.6 MHz, which is often referred to as the *calling frequency*. Of course, one of the challenges is that 29.6 MHz can get very busy, which raises the question of what other frequencies should be used for simplex. I have not found an authoritative band plan for 10 FM

simplex frequencies that addresses this issue. (Let me know if you know of one.) Many hams use 29.5 MHz as an alternative simplex frequency. For international contacts, 29.3 MHz is often used (and it is listed as the "Asia Calling Channel" on the Japan 29-MHz Band Plan). Various people have suggested using 29.2 to 29.3 MHz for FM simplex, most likely with a 20-kHz channel spacing.

Some radio operators use 29.6 MHz to call CQ and indicate that they are listening on another simplex frequency. This reduces the congestion on 29.6 MHz while still making use of it to call CQ. If you do make a contact on 29.6 MHz, remember to keep it short. Having a long ragchew on that frequency while the band is open will quickly frustrate your fellow 10-meter FM enthusiasts.

Some 2-meter and 70-cm repeaters are connected to a 10-meter FM transceiver, operating as a *remote base*. This allows hams on the repeater to experience the fun of DX on 10 meters while operating on 146 MHz or 440 MHz. Most of these remote bases are set up for 29.6 MHz and may not have the ability to change frequency. You'll sometimes hear these remote bases identifying in Morse Code on the simplex channel.

When 10-meter propagation is good, 29.6 MHz can get very busy. In fact, it can be a real mess. Signal fading is more pronounced with FM. Instead of a signal gradually fading away, the FM threshold effect causes it to disappear abruptly. It is common to lose contact with another station in the middle of a QSO as the band fades. The operating can be a bit chaotic with signals up and down and general congestion on the frequency. Be patient and have fun with it.

There is a long-established Yahoo group for discussing 10-meter FM topics. You can find it at: <http://groups.yahoo.com/group/AR29MHz-FM/>.

Tnx and 73

Thanks for taking the time to read another one of my columns on the "Utility Mode." I always enjoy hearing from readers, so stop by my blog at <http://www.k0nr.com/blog> or drop me an e-mail at the address shown on the first page of this column. 73, Bob KØNR

Figure 1. This mobile HF transceiver includes FM capability as a standard feature. (Photo courtesy rigpix.com)

Figure 2. The Alinco DR-03T FM transceiver is a single-band radio for 29 MHz. (Photo courtesy rigpix.com)

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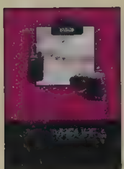

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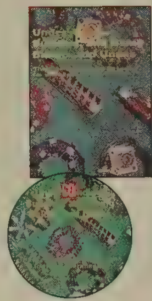

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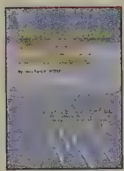

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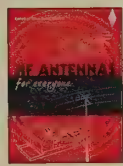

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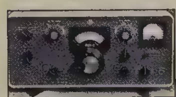

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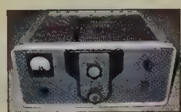

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By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

1331 Days in the Woods

Whenever you send a weather balloon aloft, you take the risk that your payload will never be seen again. This is particularly true when you land in a remote area beyond the range of any local digipeaters.

In April 2008 I flew a homebrew half-watt 30-meter transmitter on 10.142 MHz that sent the GPS position and altitude down via the unique Hellschreiber mode, as well as RTTY. In addition, it also sent the temperature, battery voltage, and pressure.

Hellschreiber is a facsimile-based digital mode that has been around since the 1920s. It is a fast on/off keyed signal that is decoded by painting each letter onto a screen. Soundcard programs FLdigi, MultiPSK, MixW, and Ham Radio Deluxe can be used to decode the mode. Hellschreiber is a weak-signal mode, since even though the signal may be well within the noise, the human eye viewing the displayed image acts as a filter to pull the image data out of the noise.

I flew a 1500-gram balloon with a PVC-pipe fitting in the end of the nozzle that had a 1/16-inch pinhole drilled into it. This was an attempt to release pressure continuously during the flight to allow the balloon to float at peak altitude instead of bursting, as it normally would.

The balloon was launched from Huntsville, Alabama about two hours before sunset. The pinhole system worked, as the balloon managed to level off at around 107,000 feet and flew into northern Tennessee.

During the end of April the stratospheric winds are very light, and the balloon hovered over one spot near Crossville, Tennessee all night long as the altitude bounced around between 97,000 and 104,000 feet.

Although the signal was weak, Barry, N4MSJ; Alan, WB5RMG; Gary, N4TXI; Todd, ALØI in North Carolina, and I all were able to decode the Hellschreiber telemetry for over 17 hours until a cou-

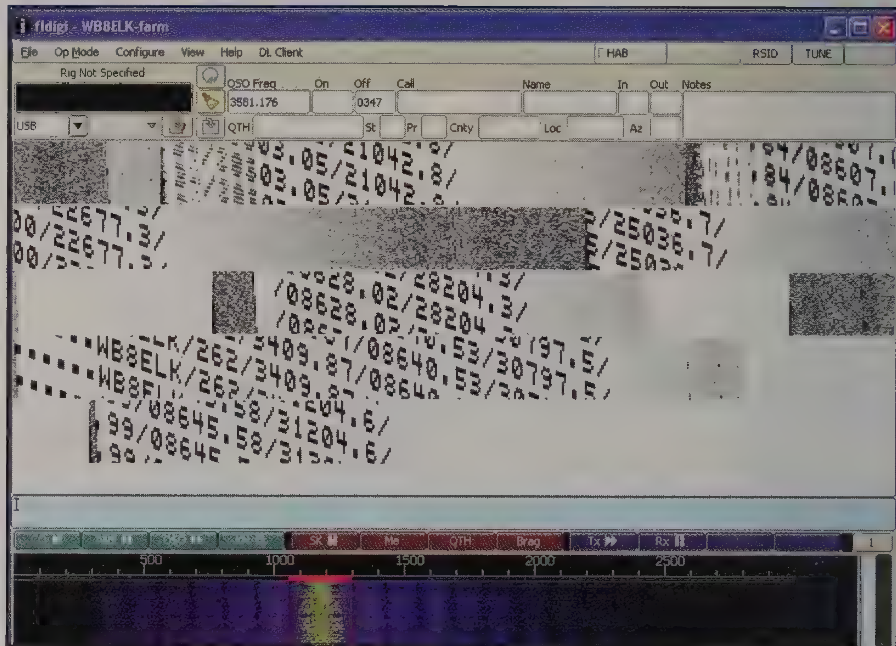

Photo 1. Hellschreiber telemetry received from the balloon payload. The extreme –45° temperatures at night shifted the timing enough to cause the characters to slant. The advantage of Hellschreiber is that even with a timing mismatch, it is still quite readable.

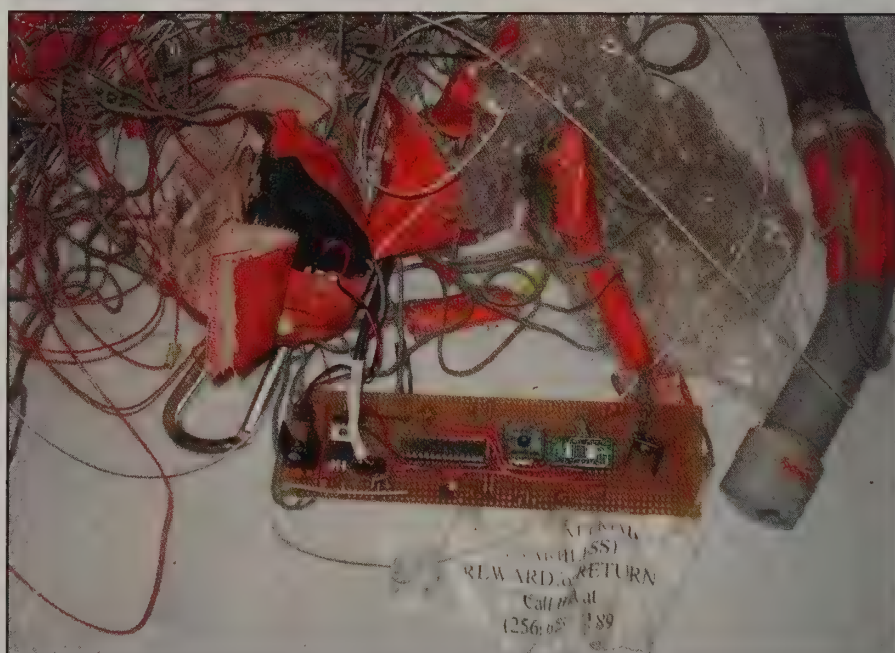

Photo 2. The tangled jumble of antenna wire and balloon payload upon its return from the wilderness. The pinhole PVC fitting and what's left of the balloon are on the right.

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e-mail: <wb8elk@aol.com>

Photo 3. Close-up of the Hellschreiber payload and faded reward sign

ple of hours after sunrise. The balloon finally burst after the intense UV radiation from the Sun degraded the latex.

The last GPS position showed the balloon about 30 miles north of Crossville, Tennessee, right on the Kentucky border near the Daniel Boone National Forest heading to the northeast. Due to the dense forests in the region, I did not expect to see the payload again, as we never received a final landing-position report.

Backup Recovery System

This past December I received a phone call from a fellow east of Somerset, Kentucky. He had just pulled out of a tree something covered in bubble wrap and badly deteriorated duct tape. He said, "I found something of yours hanging in a tree in the woods. I could read the word 'Harmless' and your phone number."

The full message said, "Balloon Experiment – Harmless – Reward." I call the reward sign my backup recovery system, and it has resulted in quite a number of lost payload recoveries over the years.

My wayward balloon payload had been sitting in the woods for 1331 days, which actually set a record for the Longest Recovery category on the Amateur Radio High Altitude Ballooning website (http://www.arhab.org).

After receiving the payload in the mail, I spread it all out on the table to see the effects of over three years of exposure in the wilderness. The duct tape was brittle, but the bubble wrap protected the transmitter board quite effectively. The solder joints were shiny with no corrosion. I decided to hook up some new batteries and was quite surprised to hear it once again send Hellschreiber and RTTY as if it was brand new.

I plan more digital-mode balloon flights on HF this year and may fly this payload once again. Hopefully it won't spend three years in the wilderness next time.

By James Duffy,* KK6MC

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

An Introduction to KK6MC

After long service as the *CQ VHF* "Beginner's Guide" column author, Rich Arland, K7SZ, has decided to move on to other things. I have the honor to be chosen as his successor. I am going to take this first column as an opportunity to introduce myself, my ham radio and VHF background, and talk a little about what I want to cover in future columns. This is your column as much as it is mine. Therefore, if you have a topic you would like me to cover or a question you would like me to answer, send me an e-mail and I will try to include it in a future column. Our VHF, UHF, and microwave spectrum is severely underused, and with the increasing demand for spectrum by various wireless entities, we stand the risk of losing much of it if we do not use it. My goal in writing this column is to get as many newcomers active on the "ultra-highs" as I can.

KK6MC in his post-Christmas pose. (Photos courtesy KK6MC)

My current VHF/UHF interests lie primarily in roving, activating different grids in a portable-mobile hybrid station, which I do in nearly every VHF/UHF contest. I have a modest roving station which consists of a Kenwood TS-2000X, an Elecraft 222-MHz transverter, and a DEMI 902-MHz transverter. The antennas all are WA5VJB Cheap Yagis, with the exception of a PAR stressed Moxon for 6 meters. I run the TS-2000X to slightly bigger antennas at the home station.

My interests in VHF operatingprimarily are weak-signal SSB/CW; future columns will have this slant. My first column will be how to get into weak-signal VHF CW/SSB operating, emphasizing the differences between VHF FM and weak-signal operations. While FM is an excellent and time-tested mode for local communications and coordinated emergency communications, the typical 5-watt handie-talkie or even the 50-watt base station with vertical antennas merely scratch the surface of what is available to the VHF operator who has even a modest station. However, getting started in weak-signal VHF/UHF operations can be a big hurdle that many beginners never get over. I am going to try to lower that hurdle in my column.

To understand and utilize VHF/UHF operations to the fullest extent, one needs to understand the propagation mechanisms associated with VHF and UHF contacts. I will devote several columns to the predominant VHF propagation modes: sporadic-*E*, troposcatter, and meteor scatter. Emphasis will be given to how QSOs with these modes differ from the line-of-sight propagation that we are familiar with on VHF FM and how best to take advantage of these modes.

I love designing and building antennas, and VHF/UHF is great for the amateur antenna builder. Dimensions are small, and gain is high. "Antennas" columnist Kent Britain, WA5VJB, has that area pretty well covered in *CQ VHF*. However, we may venture into some areas that Kent has not covered—primarily some 6-meter portable antennas.

VHF operation is conducive to operating from portable locations in rare grids and at high locations. If you are willing to spend a weekend or even a few hours away from home, you can be rare DX from a near ideal location. I rove and operate portable, so you will see a column on roving and operating portable, including discussions on selecting locations, providing adequate power, and effective antennas.

I have operated the ham radio satellites off and on since 1980 and will devote a column to how to get on the satellites with a minimum of fuss and have fun doing it. While there are several satellite-ready rigs available, and these certainly make satellite operating easier, it is possible to operate the satellites with very simple equipment.

Contesting is a passion of mine, and I operate all of the major VHF/UHF contests. Activity on these bands peaks during contests, so if you want to work lots of stations in lots of grids, you need to get

*e-mail: <KK6MC@amsat.org>

The antenna is a 2-element 6-meter Yagi that I used for roving before getting the Moxon antenna. Here I am assembling it at a rover stop in DM56.

on the air in contests. You can maximize your efforts if you know what to expect and have a plan and strategy to operate. Therefore, expect to see a column on VHF/UHF contesting as well as notices of upcoming contests in each column.

Weak-signal work on VHF and UHF has been revolutionized by the introduction of computers, digital signal processing, and software to process weak signals. I will devote a column to the most commonly used software for this application, WSJT, Weak Signal Joe Taylor. WSJT by K1JT brings meteor scatter, EME, long-distance troposcatter, airplane scatter, and ionoscatter to even modestly equipped stations. We will devote a column to getting WSJT up and running in your station.

My Background

I was first licensed in 1965 as WNØMWN in South Dakota, upgrading to a General Class license, WAØMWN, a year later. My VHF operations during this time were quite modest: for 2 meters, a Heathkit Twoer to a 3-element beam on the second story of our house. I made contacts out to 75 miles or so, but had a lot of fun. On 6 meters, I had a Johnson Ranger II and a HG-110A. I caught some sporadic-*E* on AM and CW with this setup. However, even then the SSB guys were showing that the narrow bandwidth of SSB signals was a huge advantage over AM. CW was rare in those days, as most of the occupants of the VHF bands were Technicians and Novices, whose licenses only required a 5-wpm code test.

A move to Utah in the late 1970s brought me the call N7ATB, but I was pretty inactive on the VHF bands. A move to California and an acquisition of a TX-62 led to my activity on the satellites and some local CW in the Los Angeles basin. I also acquired the KK6MC call in California when renewing my license.

We moved to New Mexico in the early 1990s, and I was inactive on the VHF bands until the late '90s, when I couldn't pass on an SB-110A offered for less than $100 at the local swap meet. I have been active on VHF ever since. The SB110A eventually gave up the ghost and I procured an ICOM IC-551D. The 551D was very convenient to operate mobile and portable, so I took up roving. After a succession of used single-band multimode transceivers for additional bands, I eventually arrived at the present KK6MC/r configuration, which I will cover in a future column.

I hope that I will learn as much from writing these columns as you do from reading them.

Until next time . . .
73 de Jim, KK6MC

By Mitch Gill, NA7US

EMERGENCY COMMUNICATIONS

The Role of VHF in EmComm

EmComm Worldwide

In this next series of columns I will be exploring emergency communications throughout the world. There are many things we all can learn from one another and it is my hope that I will be able to bring some of that to you.

RAYNET

The Radio Amateurs' Emergency Network (RAYNET), was established in the 1950s (http://www.raynet-uk.net/main/). It is the United Kingdom's voluntary communications service provided by licensed radio amateurs. I reviewed its manual, which can be downloaded at <http://www.raynet-uk.net/main/manual.asp> and found it well done, mimicking what we do in the United States when it comes to message format, phonetic alphabet, numbers, procedural words, and phrases. This is important. If there ever is traffic coming from the UK or from the US to the UK, we can rest assured that the same formats are being followed.

Another idea that comes from RAYNET is a trophy given out for services above and beyond the call of duty in the furtherance of the aims and objectives of RAYNET. I did not see anything similar in the US, but that's not to say there isn't. Here is RAYNET's criteria for the award:

• The closing date for nominations will be 1st September each year.

• The trophy will be presented at the National RAYNET annual meeting.

• The trophy will be held for 10 months, and then returned to an address specified by the Committee of Management.

• The recipient will be responsible for its safekeeping while in its possession.

• The Committee of Management will be responsible for its engraving. Upon the trophy's return, a miniature will be presented as a permanent memento.

• All members of The Radio Amateurs' Emergency Network will be eligible for nomination.

• Any individual member or group can be nominated and seconded by other members, together with suitable supporting evidence; the nomination should be endorsed by a group, county, or area controller, amateur radio zone coordinator.

• The trophy will be awarded by the Committee of Management.

• The committee's decision is final and no correspondence will be entered into.

• The Committee of Management has the right to withhold the trophy if no suitable nominations are received.

IARU

The International Amateur Radio Union (IARU) has dedicated a part of its website strictly for emergencies, and it is worth reading the many resources listed: <http://www.iaru.org/emergency/>.

RARES

The Russian Amateur Radio Emergency Service (RARES) has over 200 members. It has a 24 hour emergency frequency on HF and a VHF repeater up 150 meters. It also has a packet station with several nodes and an internet gateway server as well. You can read about what RARES has done at <www.qsl.net/rw3ah/eng/e_rares.htm>.

In Closing, This Time . . .

These are just a few examples of how amateur radio operators prepare for emergencies in other countries. After reviewing the many websites, I find comfort in knowing that almost all of them utilize other countries' information and advice to better their own country's services. There are many ideas that can be passed from one country to another, and we should share ideas.

There is so much more we can do other than just helping our own country during a crisis, and kudos to those many, many amateurs who do just that. There are numerous HF nets that have been established in which operators from different countries participate in assisting during an emergency. VHF and UHF play a major role, as well.

The accompanying table is a sample of HF and VHF traffic nets in my area. Use your favorite search engine and you will find nets in your own area or country.

Emergency communications should be a priority for amateur radio operators worldwide. I'm sure there are local repeaters near you where traffic is passed for the National Traffic System. Ask questions as to how you can help, or join your local emergency radio services. The more of us who assist during an emergency, the quicker help can arrive. Think about it!

73, Mitch, NA7US

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Pacific Area Traffic Nets (sorted by winter time)

Name	Mode	Freq. (kHz)	Summer (UTC)	Winter (UTC)	Manager
National Radio Emergency Network (NREN)	CW	7050, 10122, and 14050	All Hours	All Hours	AA8VS
National EMCOMM Traffic Service (NETS), (WRRL)	Several	Various (see list)	All Hours	All Hours	K6SOJ
Twelfth Region Net (DTWN)	SSB	3923.5	1300	1400	WGØDVH
Idaho CD Net	SSB	3990	1400 (M-F)	1500 (M-F)	WA7RQI
Washington State Net (WSN)	CW	3563, 7038, or 1818	1430	1530	W7QM
Northwest Boaters Net	SSB	3865	1530	1630	WO7O
Alaska-Pacific Emergency Preparedness Net	SSB	14292	1630 Mon-Fri	1730 Mon-Fri	AL7LX
Seventh Region Net (DRN7)	SSB	7238 or 3925; 7280 Sat & Sun	1645	1745	W7IG
Wyoming Jackalope Net	SSB	7260	1815	1915	W7ILL
Oregon Section Net	SSB	7228 or 3885	1830	1930	K7NLM

Beehive Utah Net	SSB	7272	1830	1930	NA7G
Noontime Net	SSB	3970 and 7268.5	1900	2000	W7TVA
Jefferson Noon Net	SSB	7244 (7232 alt) or 3987	1900	2000	K6SOJ
Seventh Region Net (DRN7)	SSB	7238 or 3925; 7280 Sat & Sun	2215	2315	W7IG
Twelfth Region Net (DTWN)	SSB	7233 (7228 Sunday)	2215	2315	WGØDVH
Sixth Region Net (DRN6)	SSB	7275 or 3916	2230	2330	KE6DKU
Montana Traffic Net	SSB	3910	0030	0030	AE7V
Arizona Traffic and Emergency Net (ATEN)	SSB	3986	0200	0030	KF7GC
Alberta Traffic Net (ATN) [off during summer]	CW	3685	2400	0030	VE6CPP
Wyoming Cowboy Net	SSB	3923	2345	0045	WB7K
British Columbia Emergency Net (BCEN)	CW	3652	0200	0030	VE7XLH
British Columbia Boater's Net	FM	147.32+ MHz	2400	Summer only	VE7PLN
New Mexico Roadrunner Traffic Net	SSB	3939	0100	0100	W5OXK
British Columbia Boater's Net	SSB	3855	0100	Summer only	VE7PLN
Alberta Public Service Net	SSB	3740	0030	0130	VE6AKY
British Columbia Public Service Net (BCPSN)	SSB	3729	0130	0130	VA7DR
Puget Sound Traffic System (Seattle area)	FM	146.82- MHz	0030	0130	KA7TTY
Oregon ARES Traffic Net	SSB	3990	0030	0130	N6TW
Beaver State Net	SSB	3920	0045	0145	N7CM
FARM Net	SSB	3937	0200	0200	N7KBJ
Washington Amateur Radio Traffic System (WARTS)	SSB	3975	0100	0200	K7SHE
Northwest Oregon Traffic & Training Net (NW OR, SW WA)	FM	147.32+ MHz	0105	0205	N7YSS
Oregon Section Net (OSN)	CW	3569	0130	0230	WS7L
Utah Code Net	CW	3570	0130	0230	NA7G
Northwest SSB Net	SSB	3945	0130	0230	WA7WKX
Northwest Traffic Net (Spokane, Coeur d'Alene)	FM	147.08+ MHz	0130	0230	KE7IAT
Washington State Net (WSN)	CW	3563 or 7038 or 1818	0145	0245	W7QM
Mountain States Net (MSN)	CW	3570	0200	0300	WØHXB
Idaho Montana Net (IMN)	CW	3572 or 7043	0300	0300	AI7H
West Coast Slow Speed Net (WCN)	CW (slow)	3540	0200	0300	K7WCN
Alaska Sniper's Net	SSB	3920	0200	0300	KL7GG
Northern California Net (NCN)	CW	3533	0200	0300	K9JM
Wyoming Regional Net (WYR)	CW	3560	0200	0300 Sat (Fri MST)	—
Southern California Net (SCN)	CW	3537	0200 (T & Th Pac.)	0300 (T & Th Pac.)	KI6BHB
Seventh Region Net (RN7)	CW	3560 or 7042 or 1818	0230	0330	W7IZ
Twelfth Region Net (TWN)	CW	3570 or 7063 or 1970	0230	0330	KØEZ
British Columbia and Yukon Net	SSB	3716	0230	0330	VE7DXD
Sixth Region Net (RN6)	CW	3575	0245	0345	K9JM
Pacific Area Net (PAN)	CW	3552 or 7052 or 7108 or 1835	0330	0430	K6YR
Alaska CW Net (ACWN)	CW	3540 and 7042 and 14050	0330-0759	0430-0859	AL7N
Los Angeles Net (LAN)	FM	contact KO6B	0330	0430	KO6B
Alaska Bush Net	SSB	7093	0400	0500	AL7LX
Southern California Net (Santa Barbara Section)	FM	147.00+ (PL 131.8)	0400	0500	—
Northern California Net (NCN)	CW (slow)	3533	0400	0500	WB6UZX
Sacramento Valley Traffic Net	FM	146.85	0400	0500	—
Twelfth Region Net (TWN)	CW	3570 or 7063 or 1970	0400	0500	KØEZ
Seventh Region Net (RN7)	CW	3560 or 7042 or 1818	0430	0530	W7IZ
Sixth Region Net (RN6)	CW	3575	0430	0530	K9JM
Oregon Section Net (OSN)	CW	3569	0500	0600	KC7SRL
Alaska Motley Group	SSB	3933	0500	0600	KL7GID
Traffic Handlers Net	SSB	3995	0520	0620	KB7WDP

RF Interference Patrol

Nothing can ruin the fun of operating more thoroughly than an undiagnosed noise or interference problem. Here WB6NOA describes some common interference problems and their cause(s), along with encouraging us to form our own RF interference patrols in order to locate pesky interference problems.

By Gordon West,* WB6NOA

It's time for your weak-signal net, so you flip on your old, trusty Henry 2000 amp, turn on the radio to let it warm up on frequency, and pull together the latest net news. Five minutes before the net starts, you have your mic on and volume up. The beam is pointed down range.

Hmm . . . Your usual S-2 noise level is a constant 20 over 9. You can only hear across town, so your alternate net control steps in and it is now time for noise patrol!

As consumer-electronics home appliances, gadgets, TVs, and games pour in from overseas, all of us on VHF and UHF are hit with *RF interference*. If you are diligent in your noise patrol, you sometimes can mitigate your neighbor's noise maker before that hash settles in. A VHF or UHF directional beam, plus a noise sniffer such as the portable Yaesu FT-817, can be your best sleuth arsenal.

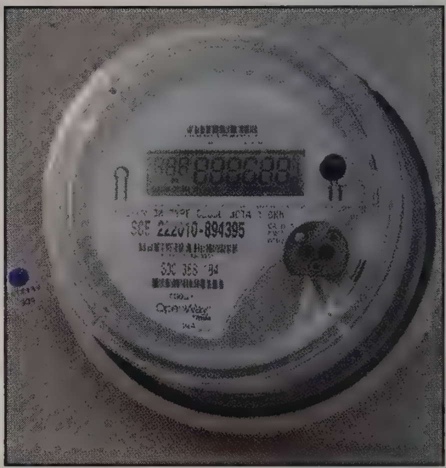
On VHF and UHF frequencies there are two major styles of radio frequency interference. *Broadband hash* masks signals throughout the band. *Birdies* are the nuisance dead carriers, which, unfortunately, seem to always pop up on 144.200 and 432.100 MHz, upper sideband!

Broadband Interference

Broadband noise is first tracked by turning off your noise blanker and then running your VHF/UHF antenna stack in a full circle. If this broadband noise remains relatively steady during your antenna rotation, it's you! Momma has a new touch lamp? Someone left the den light-dimmer knob halfway up? Did the noise begin when the installer connected and turned on the new plasma TV?

Get your rig on battery power, or run a small Yaesu FT-817 on your big stack of antennas, and locate the noise source very simply by snapping off individual circuit breakers at your QTH.

This type of residential power distribution is usually not a noise maker (top two wires) unless they arc in the wind to a nearby tree!



Smart meters don't seem to contribute to noise problems on VHF and UHF.

Ah-ha! It's coming from the garage. Check what is plugged in. There it is—the new ultrasonic rat chaser. Unplug it from the wall, and magically your broadband interference is gone!

If the broadband interference peaks at 20 over S-9 in just one direction, and almost fades out in other directions, then your beam and S-meter will give you a one-line bearing to the possible noise source. It's time to break out that FT-817 again with a little 3-element beam. When you walk down the block and you get close to the noise source, take off the beam, work with a little dual-band whip off the top of the 817, and you'll likely walk right up to the broadband noise source.

Your neighbor across the street just installed solar PV? It's not the panels, but rather the controller that might radiate broadband noise. Lucky for me (see photos), the broadband noise was curable with additional grounding, multiple donut ferrite chokes on the inside of the controller, and a bit of rearranging of some inside controller CPU conductors.

Most of these PV systems go silent when the sun begins to set, so nighttime nets may be unaffected. I had next to zero help when contacting the manufacturer for suggestions, other than a short text message that its products were all Part 15 compliant and CE; nothing else was said.

The local solar installer had no clue about RFI noise management. You will need to work with your neighbors and

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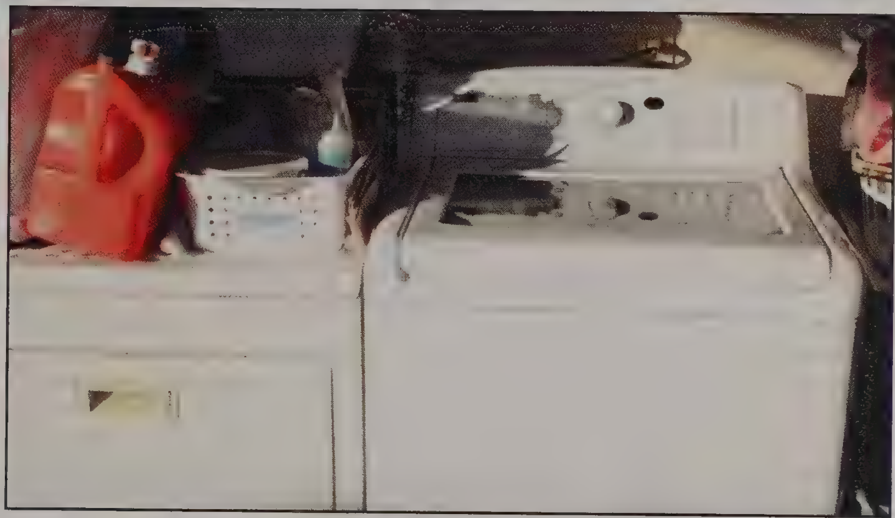
If you rotate your antenna stack and the noise remains constant, then the noise is likely coming from your own house!

This new solar install was quiet at first—until the neighbor added holiday lights via unshielded extension cords all over the roof. The white box is the controller.



The washer (right) tears up 6 meters with traveling birdies from the CPU controller.

With a low noise floor, your receiver should show no more than a half unit of S readings with the preamp off.

assure them that the snap-on chokes you are adding won't harm their new multi-thousand dollar system.

Broadband noise from major power lines is an issue you take up with your local power utility service. Many times they do have RFI inspectors, and if you have an arcing insulator down the street, they usually will schedule a switch-out.

Birdies

Lately, it is not the broadband interference that may cover your weak-signal net, but rather birdies.

A radio frequency birdie is slang for an emission leaking out of a CPU (Central Processing Unit) circuit. The birdie sounds like a steady carrier, where you may originally think someone has a pet sitting on the CW key, or if it is a fat birdie (most are not) it could be an FM operator with a stuck mic.

Start your birdie search locally—within your own house. Swing the rack of beams, and if the birdie stays relatively constant, even though you have

The charger is Pulse Width Modulated (PWM) and can be heard all the way up to 300 MHz!

decreased your RF gain control to next to zero, it's likely in your shack. If you didn't hear it a week ago, it's something you brought home the other day:

- New fax machine?
- New printer?
- New telephone answering device?
- New computer monitor?
- New whatever you just brought home

Easy fix: Pull the plug and maybe swap it for a replacement. We once installed a printer that hung a dead carrier smack dab on 144.240 MHz, our net frequency. We exchanged it for a different printer and the new printer's birdie is down below 144.000 MHz! I don't do moon bounce, so I am okay.

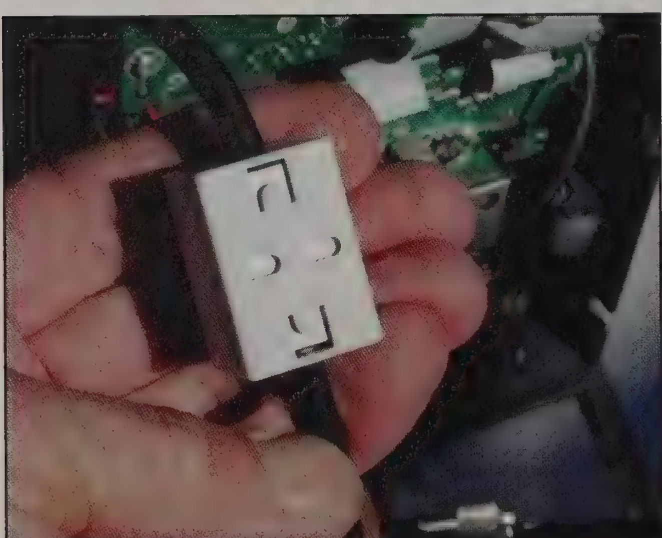
These CPU birdies usually remain constant and don't seem to drift more than a few cycles. Sometimes you can get access to the main board, and with a gloved finger (to prevent an accidental high-voltage encounter) give the board components a little capacitive touch. When you get close to the errant oscillation, you hear it immediately jump frequency. If the device uses components such as tiny tantalum capacitors, try moving them slightly and you may find that your birdie jumps out of band. Good!

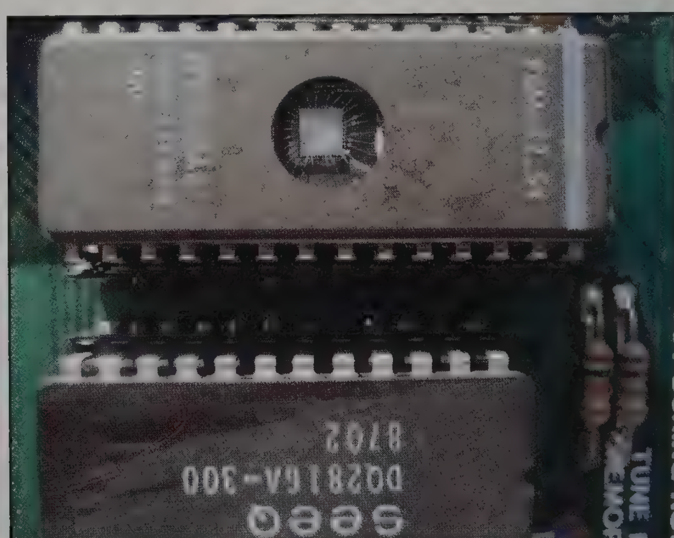
Most of these internal oscillators do not have a trimmer cap, so just fiddling around with the wires will sometimes change enough inner capacitance that the errant signal will QSY.

If the string of birdies is coming from your neighbor's house, and it just started a few days ago, try to reason with that neighbor about what they might just have brought home from their favorite home electronics store. Offer to work with them to cure the small amount of *radiation* emitting from their new equipment. That little Yaesu FT-817 will come in handy; illustrating that pulling the plug stops this radiation from escaping from this new device. Sometimes just minimizing long line cord runs may help confine that spurious emission from the oscillator.

You need to be a detective to work on these noise sources. I have a Kenmore Oasis high-efficiency clothes washer which is very efficient, *when turned on,* at generating nuisance traveling birdies (sweeps of errant signals) on high frequency, but nothing is heard on VHF and UHF. We don't do the wash when I'm on HF. My neighbor has a new switcher high-voltage power supply to run his Mylar™ banner printer, and by shortening his AC power drop the noise has almost vanished. He was happy that I found a potential source of RFI radiation.

The data bursts on 432.100 MHz—enough to knock your headphones off,


This snap-on choke helped lower a computer noise source, which was heard all over the 2-meter band.


Here is the source of birdies, which were every 20 kHz in one noise case I found. Shielding and snap-on filters helped.

day or night, every 10 minutes—turned out to be a wireless weather-station transmitter close to the beams.

Good one here: A Quartzfest® RVer was plagued with broadband "ticking" noise, all the way up through the 220 MHz band, from around noon to 3 PM. The ticking noise would go away when he started to transmit, but would come back a few minutes later. What do you think? Solar controller. When the RV solar panels would bring up the house batteries to full charge, the controller went into a pulse width modulation (PWM) interruption of charging current so as not to toast the batteries when full up. PWM at a full charge generated the ticking sound. However, when transmitting the batteries would dip slightly, the control backed off, and the noise was gone until the batteries came back up to a full state. *You got it:* Temporarily switch off the panel controller.

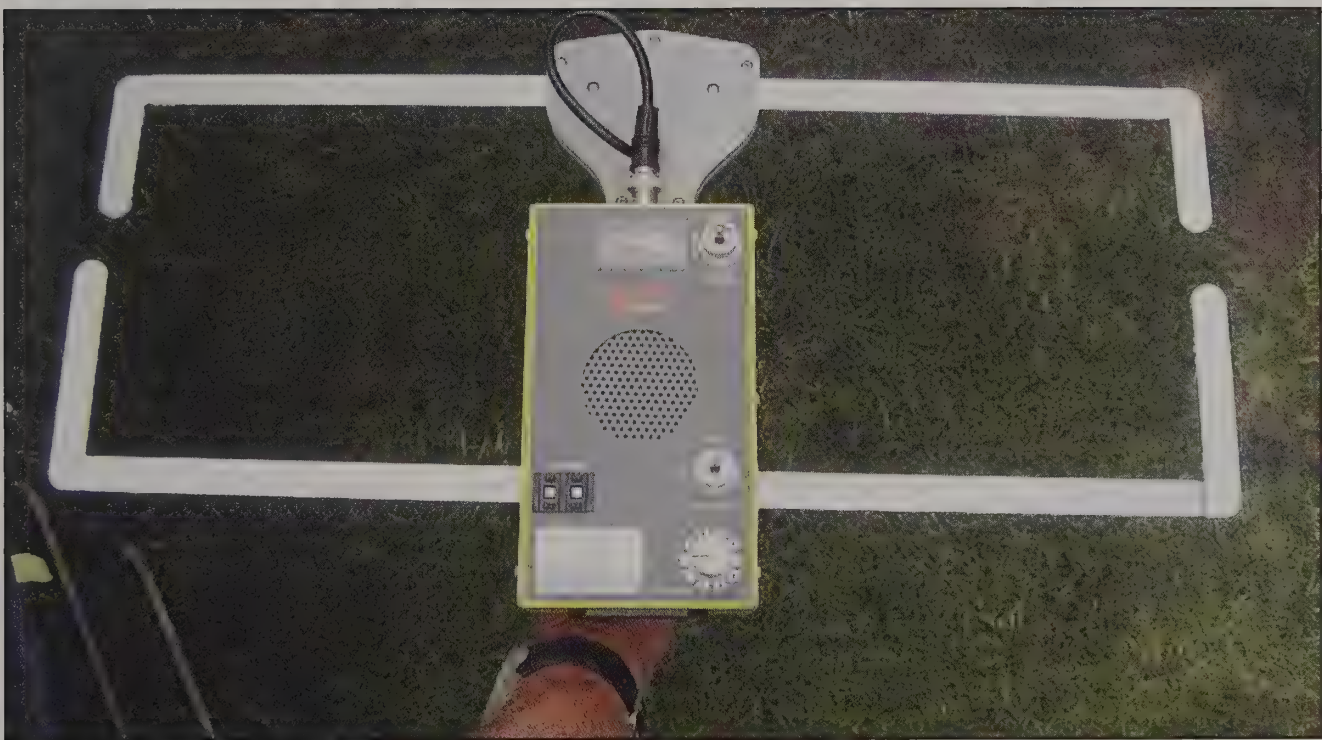
Conclusion

Don't give up when tracking down new noise sources. You must be vigilant and operate regularly so you can correlate something that has just changed in your own shack perhaps with a neighbor who just moved in with the new sound you are hearing.

Get out the little sniffer radio on SSB and keep decreasing the antenna capability to the point where you might even use a paperclip in the antenna terminal in order to zero in on a specific CPU-driven device creating the birdies, or a chopper circuit in a room dimmer half-on, blanketing the whole band with hash.

Armed with what you now know, you can form your own interference patrol and get out there to find your problem, such as that stuck mic dead carrier on 144.200 MHz, which nobody else can hear until they get within a few feet of your driveway. What treasure did you (or someone else) just bring home over the holidays that seemed to coincide with when that noise started? Now you can find the source and eliminate it.

You can sniff right up to a noise source. Behind the panel we found a noisy power supply and a switcher, with the metal cabinet removed for heat dissipation! Error!



Direction-finding (DF) foxhunt antennas can help locate a nose source. A lawn-sprinkler controller was the culprit here! Snap on chokes helped.

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Season of Lights

One man's trash is another man's treasure. Space weather and the state of Earth's geomagnetic field might be thought of in the same way. That which degrades HF (high frequency) radio propagation might create conditions for useful VHF (very high frequency) radio propagation. During times of minor to severe geomagnetic storm activity, the ionosphere loses its ability to refract HF. At the same time, however, these geomagnetic storms often trigger auroral substorms that create areas of ionization in the *E*-region of the ionosphere capable of reflecting VHF signals. This mode of propagation, sometimes called *radio aurora*, offers a challenging and exciting opportunity to increase your grid-square count.

Because of the nature of the Earth's orbit around our Sun, we have two seasons each year when any adverse space weather has a greater influence on geomagnetic disturbances. The first is known as the Spring Equinoctial season; the second is known as the Autumnal Equinoctial season. These are the two times during the course of the Earth's orbit around the Sun when the Earth is in just the right position to be most influenced by solar activity.

The Spring Equinoctial season peaks between March and April each year. It is likely this year, as we see a continued increase in solar Cycle 24 activity, that we will have significant geomagnetic disturbances to trigger the sort of auroral activity known to bring VHF activity.

Exploring past solar cycles and knowing the nature of space weather during a sunspot cycle's "rise" phase reveals that coronal holes increase as solar activity increases. With an increase in coronal holes, there is more fluctuation in the solar-wind speed, and an increase in geomagnetic storms caused by very high solar-wind conditions.

One of the "atmospheric" layers around the Sun is a region known as the corona. When a large area develops in the corona that is less dense than the surrounding area, and therefore has less magnetic structure, a *coronal hole* develops. These large-scale features are "open" magnetic-field regions that are sources of high-speed streams of solar electrons, protons, and ions (plasma). Because of the weaker magnetic structure in these holes, solar plasma easily escapes from the Sun and becomes part of the ever-present solar wind that emanates away from the Sun like water from a rotating water sprinkler.

The corona is so hot that the gases in it lose some of their electrons in the powerful collisions between atoms. This plasma is a mixture of positively charged ions and negatively charged electrons. Because plasmas are electrically conductive, they can steer, or be steered by, magnetic fields. When the plasma streams out away from the Sun through a coronal

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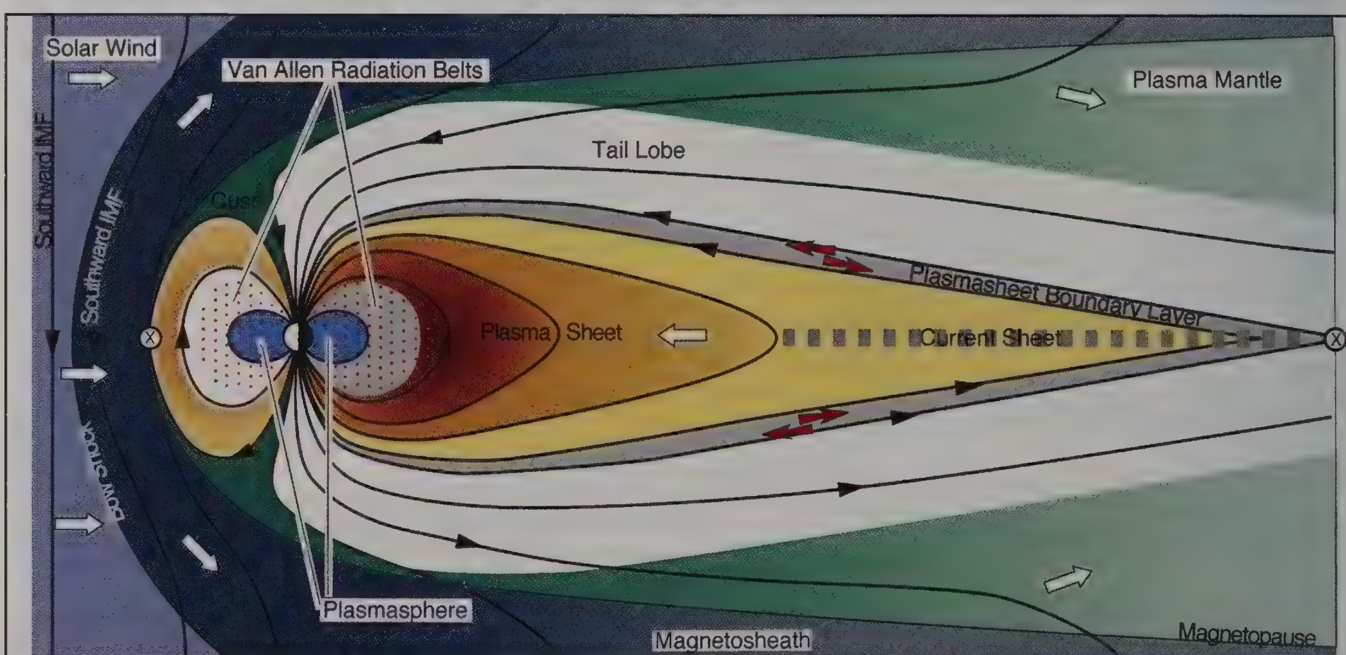

Figure 1. Earth's magnetic field gets stretched out into a comet-like shape with a tail of magnetism that stretches millions of miles behind Earth, opposite from the Sun. The Sun has a wind of plasma and magnetic-field lines that push Earth's field from the left to the right in this drawing (see text). (Credit: NASA)

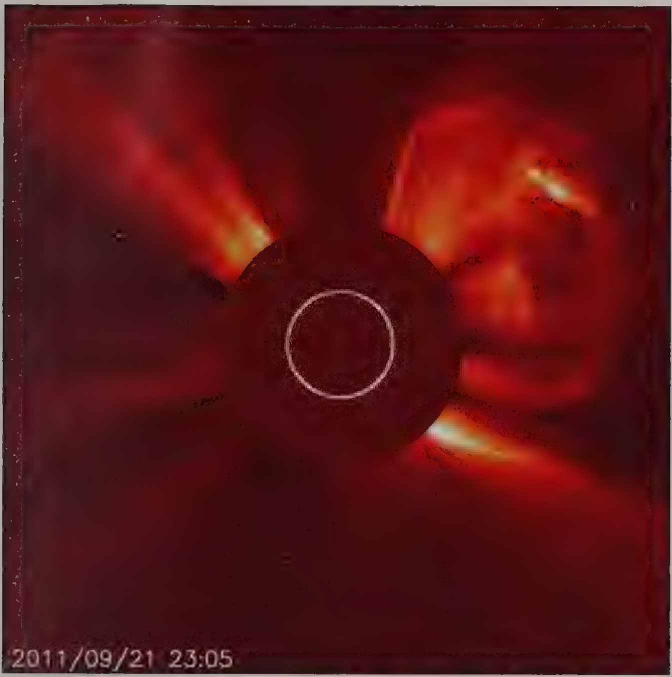

Figure 2. A CME (coronal mass ejection) bursting off the left side of the Sun. This image was captured by the SOlar and Heliospheric Observatory (SOHO) at 2305 UTC on September 21, 2011. While the solar wind is present 24 hours a day, seven days a week, and may be enhanced by coronal holes (see text), these CME events also enhance the solar wind by elevating its speed and density. The cloud of plasma, if ejected toward the Earth, rides the solar wind and will have an effect on the Earth's magnetosphere, ionosphere, and atmosphere as a coronal hole-enhanced solar wind, but on a much more dramatic scale. If the interplanetary magnetic field is oriented southward when the CME hits the magnetosphere, the shockwave from the CME will trigger a substorm, and aurora is certain, as the geomagnetic field will become highly disturbed, possibly to major storm levels. (Credit: ESA/NASA/SOHO)

hole, it drags a piece of the Sun's magnetic field with it. These loops of magnetic force are stretched and dragged into interplanetary space by the inertia of the expanding plasma and the solar wind.

The solar wind always has a magnetic component, known as the IMF (interplanetary magnetic field). When a coronal hole develops, the solar wind may include complex magnetic enhancements from these coronal holes. Additionally, the plasma that is escaping from the coronal hole also rides along the solar wind.

When the solar wind is enhanced by a coronal hole, often it causes the solar-wind speed to increase from the typical 300 to 400 kilometers per second to well over 600 to 700 kilometers per second. If this high-speed solar wind—mixed with complex magnetic forces and solar plasma—impacts the Earth, it could trigger a geomagnetic storm. The key to the triggering of a storm lies in the magnetic orientation of the IMF. If the IMF is magnetically oriented southward in relation to the Earth's magnetosphere, the two magnetic fields "recombine" and a geomagnetic storm is certain. The ability of the solar wind to disturb the Earth's magnetosphere is a function of the solar-wind

speed, the strength of its magnetic field, and the presence of a strong southward magnetic-field component.

Many years of auroral observations reveal that peak periods of radio aurora occur close to the equinoxes—that is, during the months of March and April, and again in September and October. Of the two yearly peaks, the greater peak, in terms of the number of contacts reported, occurs during October. However, some of the strongest levels of geomagnetic storms are in the spring. The minimum yearly activity occurs during the months of June and July, with a lesser minimum during December.

When active aurora is seen in the auroral zone, a strong magnetic disturbance is usually also observed there. These disturbed magnetic fields often are much stronger than those of a geomagnetic storm but are strictly local, fading away quickly as one moves equator-ward. This suggests that the currents that disturb the magnetic fields flow somewhere nearby—probably near the auroral arcs.

The Norwegian physicist Kristian Birkeland (whose portrait appears on Norwegian currency) carefully observed auroral disturbances and concluded that the currents flow parallel to the ground, along the auroral formation. Because electrical currents must flow in a closed circuit, and because these magnetic disturbances seemed to be caused by processes taking place in distant space, Birkeland proposed that the currents come down from space at one end of an arc and returned to space at some other end.

In 1910 Birkeland performed a series of experiments to reproduce many of the characteristics of the aurora that he observed during his expeditions. He placed an electromagnetic sphere, coated with fluorescent paint, inside a vacuum chamber and projected a beam of electrons at the sphere. This enabled him to view the trajectories of streaming electrons. Birkeland was able to accurately reproduce how solar wind would make its way into the Earth's magnetic poles, and was able to simulate the auroral ovals near the Earth's magnetic poles.

It was finally in 1954 that auroral electrons actually were observed by sensors aboard a rocket launched into an aurora by Meredith, Gottlieb, and Van Allen, of Van Allen's team at the University of Iowa. The Van Allen team discovered Earth's radiation belts, now called the Van Allen Belts.

Continuous research has revealed that aurora is caused by the large-scale interaction between the Earth's magnetic field and the solar wind. The magnetic field around the Earth is distorted by a flow of charged particles, mainly protons and electrons, which flow away from the sun. On the windward side, the side mostly facing the Sun, a bow shock is formed, while on the leeward (opposite) side, the magnetosphere is dragged out into a long tail. This magnetosphere acts as a giant shield around the Earth, blocking the solar-wind particles.

However, there are distinct regions in the magnetosphere where solar-wind particles may enter the Earth's upper atmosphere. Solar-wind particles can enter directly via the dayside cusps, or, having been trapped in the plasma sheet around the Earth, they can enter via the enclosed magnetic-field lines at the polar auroral oval on the night side.

The aurora is a dynamic and often visual phenomenon caused by energized solar plasma particles riding down the Earth's magnetic-field lines toward the north and south magnetic poles. When these particles strike the molecules and atoms of the thin, high atmosphere, photons are released, creating a light show consisting of different colors.

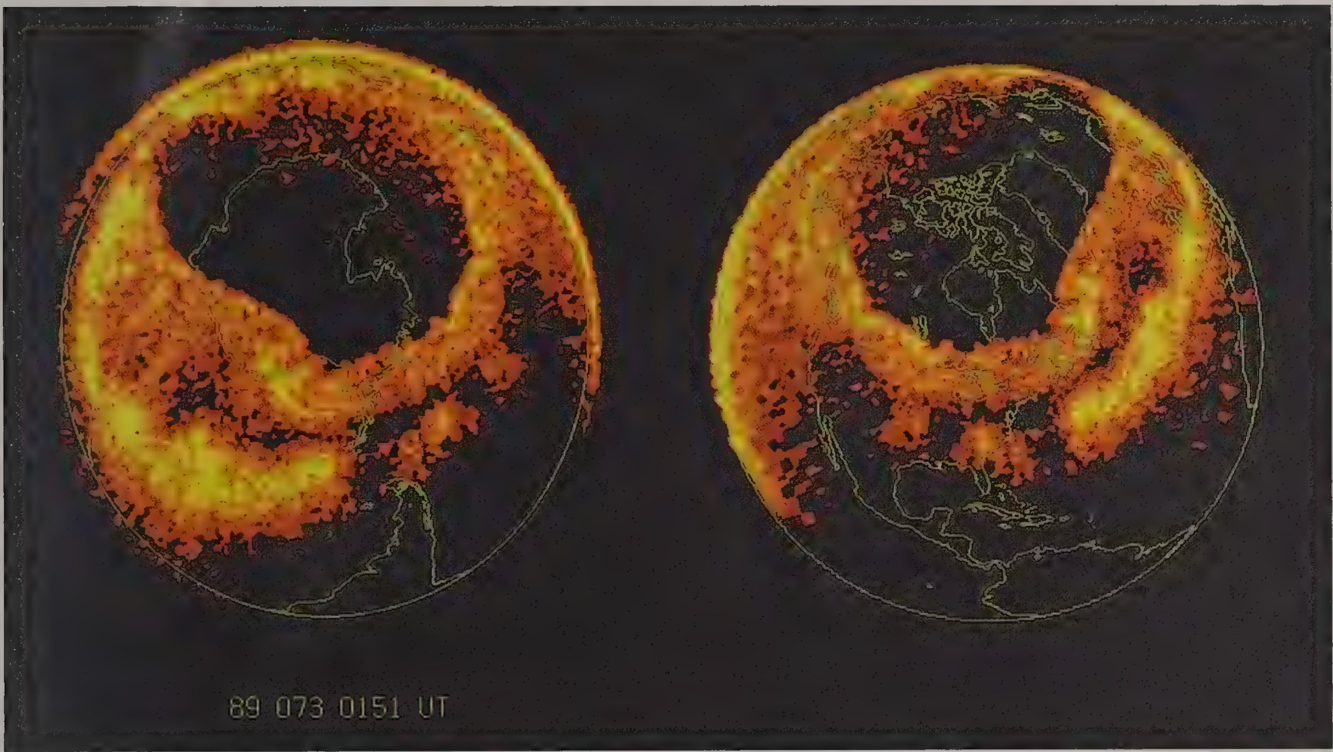

Figure 3. The image on the left shows an extremely large aurora that occurred March 14, 1989 at 0151 UTC over the southern polar regions. The picture on the right is a re-mapping of that image into the Northern Hemisphere to give an idea of what the auroral oval would have looked like if the spacecraft had been over the Northern Hemisphere at this time. From this image you can see that you would have been able to see the aurora in Texas and Florida. During such an event radio aurora is certain; working stations on the 6-meter amateur radio band by way of the E-region ionization that occurs during an auroral even is possible during intense aurora activity. (Credit: NASA)

To understand why, take a look at a neon light. When a neon light is energized, you are looking at an interaction of electrons with the gases inside the tube, resulting in plasma. Plasma conducts electricity and is also steered by magnetic fields. The color of the neon light depends on the gas that fills the tube. On a much larger scale, the solar plasma riding the solar wind is shaped by the magnetic-field lines found in the magnetosphere and produces colors depending on the gases found at the various altitudes through which the plasma passes.

You can view a fascinating video that explains all of this by watching the video "The Fantastic Aurora: Inside the Sun to Earth's Poles" at: <http://g.nw7us.us/xqKg2c>.

During this interaction which results in a dramatic light show, ionization also occurs at an altitude of about 70 miles, very near the *E*-layer of the ionosphere. The level of ionization depends on the energy and number of solar-wind particles able to enter the atmosphere. To the delight of the VHF communications enthusiast, propagation off the *E*-region auroral ionization is an exciting activity.

While correlations exist between visible and radio aurora, radio aurora could exist without visual aurora. Statistically, a diurnal variation of the frequency of radio aurora QSOs has been identified tand suggests two strong peaks, one near 6 PM and the second around midnight, local time.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter with the geomagnetic field line equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval and the possible intensity of the aurora. When the *K*-index is higher than 5, most readers in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida.

Expect an increase in geomagnetic storms and auroral activity as we move through March and into April. For the daily conditions, you are welcome to check my propagation resource at <http://sunspotwatch.com>, where I have the current planetary *K*-index, links to various aurora resources, and more.

Meteors

While there are no major meteor showers during February and March, April has one major meteor shower, the *Lyrids*, which peak on April 22 at 0530 UTC. While this shower peaks at about 18 meteors per hour, this year many more radio bursts will occur than can be seen by the unaided eye. Predictions call for a

possible peak as high as 90 per visual meteors per hour.

From January through March there are small events that most people won't even consider, because they don't yield any visual success. However, the VHF radio meteor hunter can find that even during days with minimal activity some meteor-scatter propagation may exist.

In two videos by KB3RHR from February 2011, in which he demonstrates some meteor-scatter communication between his station and several other stations located outside his local area, you can hear the raspy audio of the signals, and the variable strength as the signals fade in and out due to the quickly changing nature of the plasma-trail ionization from the passing meteors. The first video can be seen by browsing to <http://g.nw7us.us/yEunPI>, while the second is at <http://g.nw7us.us/yiPtZf>.

Figure 4. This image as seen through the 193-Angstrom wavelength filter of the Solar Dynamics Observatory's Atmospheric Imaging Assembly instruments reveals a large coronal hole that is just entering into the "geo-effective" zone of the Sun. The geo-effective zone is the area on the Sun that "lines up" with the Earth by way of the solar wind. The solar wind does not blow straight out away from the Sun, however. It follows a spiral (the Parker Spiral). When a coronal hole rotates into the geo-effective zone, the solar plasma escaping the gravity of the Sun at high speed races out toward the Earth and typically causes geomagnetic disturbances and even storms (and in turn may trigger aurora). (Source: Solar Dynamics Observatory [SDO]/Atmospheric Imaging Assembly [AIA])

The Solar Cycle Pulse

The observed sunspot numbers from October through December 2011 are 88.0, 96.7, and 73.0 (compared with a year ago; 23.5, 21.6, and 14.5). Note that November's 96.7 is the highest monthly observed sunspot count yet (at press time) of solar Cycle 24. The smoothed sunspot counts for April through June 2011 are 41.8, 47.6, and 53.2 (much higher than a year ago: 14.0, 15.5, and 16.4).

The monthly 10.7-cm (preliminary) numbers from October through December 2011 are 137.2, 153.1, and 141.2 (significantly up from a year ago: 81.6, 82.5, and 84.3). The smoothed 10.7-cm radio flux numbers for April through June 2011 are 100.4, 105.6, and 110.9 (up from 78.3, 79.0, and 79.7 a year ago).

The smoothed planetary *A*-index (*Ap*) numbers from April through June 2011 are 7.5, 7.5, and 7.3, staying consistently quiet. The monthly readings from October through December 2011 are 7, 3, and 2, indicating a rather quiet Sun, even with the higher sunspot activity. This has scientists speculating about a possible overall decline in solar-cycle energy. We'll explore this idea in more detail in a future column.

The monthly sunspot number forecast for February through April 2012 is 83 for each month. The monthly 10.7-cm radio flux is predicted to be a steady at 144 for all three months. Give or take about eight points for all predictions. Keep in mind, however, that these numbers can easily change, as the Sun is not a mechanical device running like a clock; the Sun is a dynamic star, with complex internal processes that we don't yet understand. These forecasts can easily change, as they have already. In any event, the monthly averages are moving up, and that's good news, as we're seeing improvement in *F*-region propagation higher and higher in the radio spectrum.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter, etc.). I'll create summaries and share them with the readership. I look forward to hearing from you. You are also welcome to share your reports at my public forums at <http://forums.hfradio.org/>. Up-to-date space weather and radio propagation information is found at the NW7US Space Weather and Radio Resource Center: <http://sunspotwatch.com/>.

If you are using Twitter, follow @hfradiospacewx for space weather and propagation alerts, and follow me @NW7US to hear about various topics, including space weather and amateur radio news. Facebook members should check out the CQ VHF Magazine Fan Page at <http://www.facebook.com/CQVHF>, and the Space Weather and Radio Propagation Group at <http://www.facebook.com/spacewx.hfradio>.

Until the next issue, happy weak-signal DXing.

73, Tomas, NW7US

CQ's 6 Meter and Satellite WAZ Awards

(As of January 1, 2012)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,6,7,12,18,19,22,23,28,31
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,184OM,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39.
86	WB8TGY	16,17,18,19,21,22,23,24,26,28.29,30,34,36,39
87	MUØFAL	1,2,12,18,19,22,23,24,26,27,28,29,30,31,32
88	PY2BW	1,2,17,18,19,22,23,26,28,29,30,38,39,40.
89	K4OM	17,18,19,21,22,23,24,26,28,29,32,34,36,38,39.
90	JHØBBE	2,33,34,40
91	K6QXY	17,18,19,21,22,23,34,37,39
92	JA8ISU	2,7,8,9,19,33,34,36,37,38,39,40
93	YO9HP	1,2,6,7,11,12,13,18,19,23,28,29,30,31,40
94	SV8CS	1,2,6,7,18,19,23,26,28,29
95	SM3NRY	1,6,10,12,13,19,23,25,26,29,30,31,32,39
96	VK3OT	2,10,11,12,16,34,35,37,39,40
97	UY1HY	1,2,3,6,7,9,12,18,19,23,26.28,31,32,36
98	JA7QVI	2,40
99	K1HTV	17,18,19,21,22,23,24,26,28,29,34
100	OK1RD	2,6,7,8,9,11,12,13,18,19,21,22,28,39,40
101	S51DI	1,2,6,18,19
102	S59Z	1,2,6,7,10,12,17,18,19,22,23,24,26,31,32
103	UY5ZZ	1,2,3,6,7,10,11,12,13,18,19,29,31,32,39
104	UXØFF	1,2,6,7,10,12,13,18,19,22,28,29,31,32
105	EI3IO	1,3,12,18,19,23,29,30,31,32
106	JJ2BLV	2,4,5,7,8,9,16,18,19,34,35,36,37,38,40
107	EA6SX	1,2,10,12,18,19,22,26,27,28,29,30,31,32.
108	PE5T	1,2,3,6,12,18,19,22,27,29,30,31,32,39

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40
24	XE1MEX	19 Mar. 09	2,17,18,21,22,23,26,34,37,40
25	KCØTO	17 Mar. 11	None

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, P.O. Box 449, Wiggins, MS 39577-0449. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

P.O. Box 449, Wiggins, MS 39577-0449; e-mail: <n5fg@cq-amateur-radio.com>

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

The Forgotten Band: 902–928 MHz

This time we will go over a family of antennas for the 33-cm band. For hams there will be versions for the low end of the band; for experimenters, versions for the middle of the band.

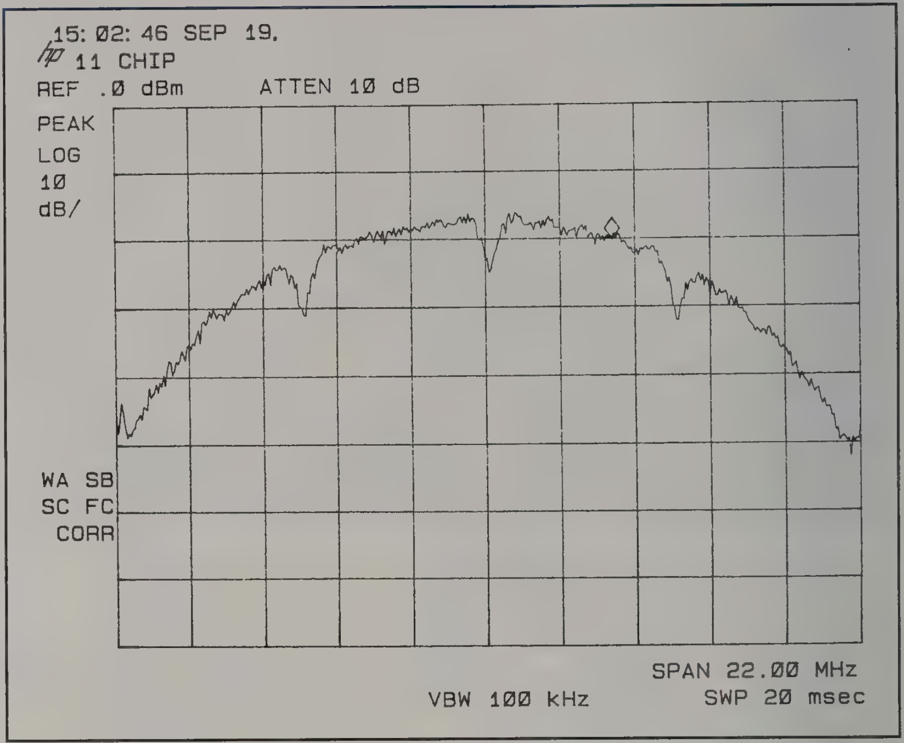

Figure 1. Spread spectrum.

Band Occupancy

I will start out explaining a bit about all those FCC Part 15 noise generators with which we share the 902–928 MHz band. Figure 1 is the plot from a direct-sequence spread-spectrum transmitter I had to get though FCC compliance testing many years ago. Note how the signal is strongest in the middle of the band, tapering off at the edges. This is typical for most spread-spectrum transmitters.

This next number shown graphically in figure 2 gets a bit complex, depending on the Part 15 device's antenna gain and duty factor. However, between 902.001 MHz and 901.999 MHz the emissions of the device must drop 75 dB –75 dB attenuation in 2 kHz, which is quite a filter even if you do make it out of super conductors. With modulation sidebands, phase noise from the local oscillator and intermod products in the transmitter chain, the signals are just too wide for these inexpensive ("cheap") devices to operate anywhere near the edges of the 902–928 MHz band and still pass FCC Part 15 testing. This gives us two holes with a lower noise floor in the first few kHz and the last few kHz of the band.

With a special temporary authority (STA) from the FCC, 30 years ago Don Hillard WØEYE/WØPW did much of the early work with 902-MHz ham rigs before it was even a ham band. Don published a large family of transmitters, receivers, local oscillators, power amps, filters, multipliers, and antennas for 902 MHz. I was fortunate to get his two books and these are now available as PDFs. You can download them from the Reference Section at <http://www.wa5vjb.com>. While you are at it, thanks to the work of WA1ZMS, the *Proceedings* of the first two Microwave Update conferences are also available as downloads in the same directory. A lot of other good UHF and wicrowave projects are in those *Proceedings* as well.

WØPW chose 902.100 MHz for the majority of his work. Most of the hams getting on the 902-MHz band followed Don's lead and designed our stations around the 902.1-MHz SSB/CW calling frequency. Up in the Philadelphia area there were a large number of surplus crystals that when used in a local oscillator make 903.1 MHz come out at 144.1 MHz. Thus we ended up with 903.1 MHz as the SSB/CW calling frequency in much of the northeast, and 902.1 MHz as the SSB/CW calling frequency in most of the rest of the U.S. During band openings it has been easier for the 902.1 lads to tune their IF rigs to 145.1 MHz and make a QSO on 903.1, than it has been for the 903.1 chaps to tune their IF rigs down to 143.1 MHz for a 902.1 QSO. So these days there are advantages to ordering a transverter crystaled for 902 vs 903 MHz if you like working tropo DX.

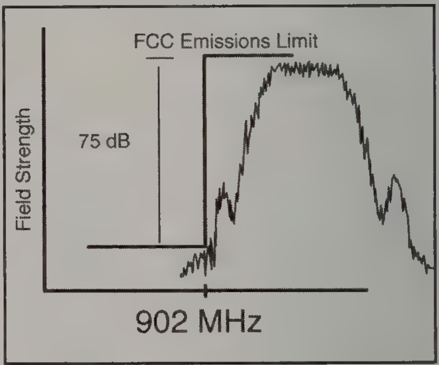

Figure 2. FCC field-strength limits.

However, it may be time to look at a new calling frequency, especially for CW/SSB stations in urban areas. The 900-MHz noise floor is getting worse and worse, but these noise makers can't operate near the

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edges of the band. There is a lot to be said for a new CW/SSB calling frequency of 902.01 or perhaps 902.025 MHz to avoid much of the spread-spectrum and frequency-hopping RF systems out there. Contest stations take note: Those far-away grid multipliers just might be easier to work near the band edge.

FYI, two years ago I worked with a 900-MHz smart utility meter company to produce a 900-MHz noise floor map of Joplin, Missouri. By far the largest noise source was a Walmart with their dozens and dozens of RFID and Barcode readers.

In photo 1 is one of the first Yagis I built around the J-driven element 20 years ago. Boy, that shows two things: How long I have been working with the family of "Cheap Yagis" and how much of a packrat I am. Ever watch the show "Hoarder's"? I'm not quite eligible yet, but watching that show does remind me to make another pile for the recycling bins. This antenna was the prototype for a family of Yagis made just for 915 MHz direct-sequence spread spectrum.

For the experimenters out there, we also have a family of 2-, 3-, and 4 element Yagis centered around 915 MHz. These smaller antennas are very handy for bench experiments with RFID, biomedical, and data communications.

For hams, the longer 915-MHz Yagis can be used with High Speed Multi Media (HSMM) systems. There are also a fair number of ATV systems using 915-MHz

Antenna Dimensions

	R	DE	D1	D2	D3	D4	D5	D6	D7	D8	D9
915 MHz											
2-Element											
Length	6.5	**	—	—	—	—	—	—	—	—	—
Spacing	0	1.3	—	—	—	—	—	—	—	—	—
Gain 4 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 10 dB	—	—	—	—	—	—	—	—	—	—	—
3-Element											
Length	6.4	**	5.3	—	—	—	—	—	—	—	—
Spacing	0	2.5	5	—	—	—	—	—	—	—	—
Gain 7 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 17 dB	—	—	—	—	—	—	—	—	—	—	—
4-Element											
Length	6.3	**	5.7	5	—	—	—	—	—	—	—
Spacing	0	2.4	3.5	5.3	—	—	—	—	—	—	—
Gain 8.2 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 25 dB	—	—	—	—	—	—	—	—	—	—	—
6-Element											
Length	6.3	**	5.7	5.6	5.5	5.2	—	—	—	—	—
Spacing	0	2.4	3.5	5	8.3	12	—	—	—	—	—
Gain 11 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 22 dB	—	—	—	—	—	—	—	—	—	—	—
10-Element											
Length	6.3	**	5.7	5.6	5.6	5.3	5.3	5.3	5.3	5	—
Spacing	0	2.4	3.5	5	8.3	12	15	18	21	24	—
Gain 12.5 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 30 dB	—	—	—	—	—	—	—	—	—	—	—
	—										
902 MHz											
11-Element											
Length	6.4	**	5.8	5.8	5.6	5.6	5.5	5.5	5.4	5.2	5.2
Spacing	0	1.5	3.5	5.8	8.3	12	14	17	20	24	27
Gain 13 dBi	—	—	—	—	—	—	—	—	—	—	—
F/B 30 dB	—	—	—	—	—	—	—	—	—	—	—

Table 1. All dimensions are in inches. All designs use the driven element in figure 3. All spacings are measured from the reflector element. All elements are 1/8-inch or .125-inch diameter rod.

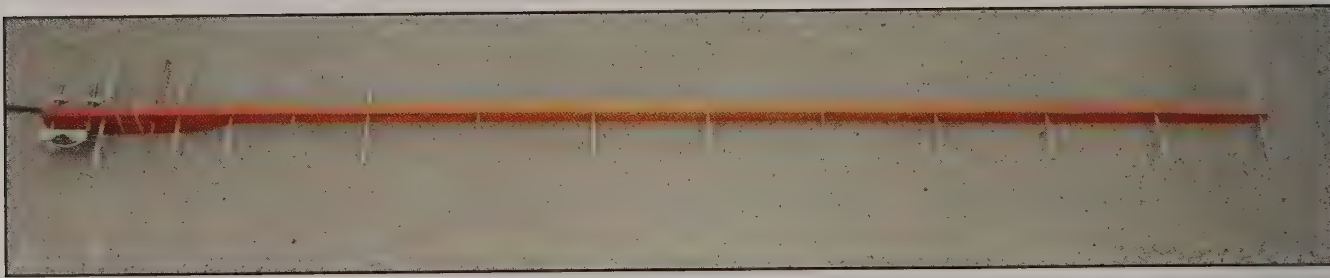

Photo 1. Long 915-MHz Yagi.

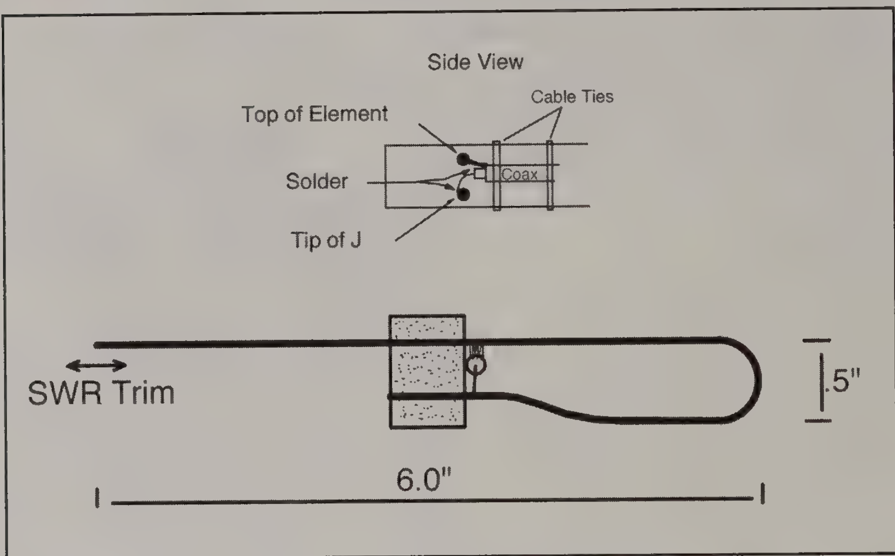

Figure 3. Driven element for all versions.

Photo 2. Close-up of coax attachment.

FM video; these antennas can find a home with your video transmitters.

For the CW/SSB rovers and contesters, we have an 11-element Yagi you can build pretty inexpensively and save those pennies for gas and DSP filters.

The driven element is shown in figure 3. The width of the loop is not critical, but don't stray too far from these dimensions. The coax is soldered directly to the driven element. The shield goes to the center of the long part of the "J," and the coax center conductor goes near the tip of the "J." If you have the test equipment, the tip of the driven element can be trimmed for best SWR. If you just build the antenna to the dimensions, the SWR is typically about 1.5 to 1.

The elements can be bronze welding rod, aluminum rod, hobby tubing, or #12 copper wire. For the boom I used wood. The elements are tuned to pass through about $^1/2$ inch of wood. If the antenna is built with 1" × 1" wood, the antenna will be 10–20 MHz low in frequency. So $^1/2$" × $^1/2$" or $^1/2$" × $^1/4$" wood is recommended. If the antenna is going to be outside for long periods of time, a coat of paint or varnish will greatly extend the life of the antenna.

Future Projects

That second 20-element 432-MHz Cheap Yagi is still on my get-around-to-it list, and how to stack the two for vertical, horizontal, left-hand, or right-hand circular polarization. However, I do promise to have that built and written up before Aercibo is on EME again.

As always we welcome antenna questions and column suggestions from our readers. Many a column topic has been suggest by you, our readers. E-mail to <wa5vjb@cq-vhf.com>, or <wa5vjb@amsart.org> will work. And for several dozen other antenna projects, you are welcome to visit <http://www.wa5vjb.com> and look in the Reference section.

73, Kent, WA5VJB

for consultation and collaboration when the Protocols were first penned. Putting aside for just a moment the question of who constitutes a "party to this declaration," a very different reality exists today.

In addition, by implication the Protocols dictate that the researcher may not inform other observers who are not a party to this declaration (such as asking another radio astronomer to take a look at an interesting candidate signal), lest the "SETI Police" appear and lock up that researcher in a "Faraday Cage":

> Parties to this declaration should not make any public announcement of this information until it is determined whether this information is or is not credible evidence of the existence of extraterrestrial intelligence.

This constraint might have been feasible before the advent of the internet; it no longer is. If anything in recent experience seems to defy Einsteinian physics, it is the fact that the spread of information in cyberspace appears to exceed the speed of light.

"The discoverer should inform his/her or its relevant national authorities": Which national authorities, when observations are now being made by global organizations with members residing in well over a hundred different countries? And who determines which authorities are "relevant"?

> After concluding that the discovery appears to be credible evidence of extraterrestrial intelligence, and after informing other parties to this declaration, the discoverer should inform observers throughout the world through the Central Bureau for Astronomical Telegrams of the International Astronomical Union, and should inform the Secretary General of the United Nations in accordance with Article XI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Bodies.

After who concludes that the evidence is credible? Central Bureau for Astronomical Telegrams? How quaint! (Does anyone even send telegrams anymore?) And how many of today's SETI participants ever heard of that particular treaty article, let alone understand its implications?

> Because of their demonstrated interest in and expertise concerning the question of the existence of extraterrestrial intelligence, the discoverer should simultaneously inform the following international institutions of the discovery and should provide them with all pertinent data and recorded information concerning the evidence: the International Telecommunication Union, the Committee on Space Research, of the International Council of Scientific Unions, the International Astronautical Federation, the International Academy of Astronautics, the International Institute of Space Law, Commission 51 of the International Astronomical Union and Commission J of the International Radio Science Union.

Frankly, I wouldn't know how to begin to get in touch with all of those bodies, and I've been involved in SETI science and technology for decades!

> No response to a signal or other evidence of extraterrestrial intelligence should be sent until appropriate international consultations have taken place.

Imagine trying to tell a radio amateur licensed by his or her country to emit electromagnetic radiation and to refrain from transmitting until appropriate international consultations have taken place.

> The International Academy of Astronautics will act as the Depository for this declaration and will annually provide a current list of parties to all the parties to this declaration.

If you happen to be a SETI League member, you already know how difficult it is to maintain a current membership list of just our small organization, not to mention the challenges of providing same to all of our members. Besides, do you even want to receive an annual e-mail with the names and addresses of all 7-million SETI@Home participants?

The Protocols go on, as does the list of objections. Clearly, this is a document that has failed to keep up with the times. Revision is not just due, it is long *overdue*.

Five years ago the IAA SETI Committee began revisiting the Protocols. It was an arduous process, requiring not only technical expertise, but also legal and political input, and it dragged on. Finally, after drafting numerous versions and incorporating revisions suggested by the International Institute of Space Law (IISL), simplified and revised protocols were unanimously adopted by the SETI Permanent Study Group of the International Academy of Astronautics at its annual meeting in Prague, Czech Republic, on 30 September 2010. The significantly shorter, more succinct document, now entitled "Declaration of Principles Concerning the Conduct of the Search for Extraterrestrial Intelligence," was submitted straightaway to the IAA Board for adoption.

Then the fun began. At its Paris office in March 2011, the Academy reorganized its committee structure, terminating the SETI Permanent Study Group and replacing it with a SETI Permanent Committee. It was a change in name only, as the membership roster remained the same. However, the very people who had drafted and unanimously adopted what is now being called the "revised Protocols" was tasked with revisiting it, and considering it for either revision or resubmission to the Academy.

As this is being written, it is October 2011, and I am enjoying a balmy spring day in Cape Town, South Africa, chairing a meeting of the SETI Permanent Study Group (pardon me, I meant the SETI Permanent Committee). The Committee has once again recommended adoption of revised Protocols. Unfortunately, the new president of the IAA has already stipulated that this recommendation should be acted upon by the newly elected, incoming Academy Board (which has yet to be brought up to speed on the issues), rather than the outgoing board (which has already accepted these revisions). Thus, it will be some time before we can expect the board to act. I wouldn't be surprised if, following any such action, the document will then be resubmitted to the IISL before it ever sees light in UN chambers. Let us hope that SETI success doesn't come too quickly, lest we be bound by an obsolete document and find ourselves hog-tied.

On the other hand, we've yet to achieve SETI success after a half-century of observation. What's another decade or two to the bureaucrats?

For those who are interested, the revised Protocols can be found on The SETI League website at <http://www.setileague.org/iaaseti/protocols_rev2010.pdf>. Be sure to clear your browser cache when you take a look, as they've probably changed while I was typing this.

73, Paul, NN6TX

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

The Politics of Protocols

or How I Spent My (Southern Hemisphere) Spring Vacation

Back in the 1980s, the key players in the SETI enterprise were primarily large, government-sponsored agencies such as NASA in the United States and the Russian Academy of Science in the Soviet Union. Not only was there little room for small, independent research organizations, there was little need for them. SETI was more or less a closed community, which made its own rules.

Acting under the auspices of the International Academy of Astronautics (IAA), that small community convened a series of meetings to forge a set of protocols intended to bring order to the chaos which was expected to follow an actual SETI detection. The result of that effort was a document published in 1989, adopted by the IAA, and submitted to and accepted by the United Nations Committee for the Peaceful Uses of Outer Space (UN-COPUOS) with the suitably bureaucratic title "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence" (but universally referred to simply as the "SETI Protocols").

With the subsequent end of the Cold War came a significant curtailing of funding, on both sides of the once Iron Curtain, for large-scale scientific endeavors. I suppose that's one of the costs of deciding to wage peace. Soon the NASA SETI program was terminated, and with it equivalent projects in the former Soviet states. Thus began a gradual shift toward privatization, and democratization, of global SETI. The very existence of The SETI League is beholden to this shift. As we and similar organizations (not to mention quite a few unaffiliated individuals) stepped in to fill the void left by the demise of government-sponsored SETI, the SETI Protocols began to appear irrelevant.

As Dr. Seth Shostak, N6UDK, Chairman of the IAA SETI Permanent Study Group, recently wrote to the IAA leadership team, "in recent years, the IAA SETI PSG has elected to revisit these protocols with the intention of (1) streamlining both the wording and the intention, and (2) removing ambiguities and obvious impediments to utility."

So what exactly was wrong with the original SETI Protocols, which were themselves several years and many debates in the making? Very little, in the context of the political, economic, and scientific realities which served as their backdrop. It's just that they haven't kept up with the times.

For one thing, the Protocols were only binding upon their signatories (which, at the time, constituted just about everyone in the world involved in SETI science). Certainly, the several hundred SETI League members who became involved in this research over the past 17 years were not bound by the terms of the Protocols (except, perhaps, by implication, as The SETI League itself is signatory to them). Nor were several dozen unaffiliated ham radio operators worldwide who continue to pursue SETI science on the cheap. Nor were the 7-million worldwide individual contributors to the popular SETI@Home distributed computing experiment, any one of which could well have been the person to achieve contact. Written by and for professional SETI scientists, the Protocols never contemplated regulating the activities of the masses.

Consider some of the specific language in the original Protocols:

> Prior to making a public announcement that evidence of extraterrestrial intelligence has been detected, the discoverer should promptly inform all other observers or research organizations that are parties to this declaration, so that those other parties may seek to confirm the discovery by independent observations at other sites and so that a network can be established to enable continuous monitoring of the signal or phenomenon.

All other observers or research organizations were, of course, readily reachable

Members of the international SETI community (many of them hams) met over dinner and wine in Cape Town, South Africa in October 2011 to revisit the SETI Detection Protocols.

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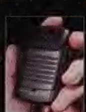

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